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MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

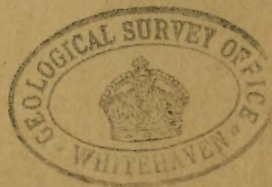
ENVIRONMENTAL STORAGE

VOL. XXIII.—LEAD AND ZINC ORES IN
THE PRE-CARBONIFEROUS ROCKS OF
WEST SHROPSHIRE AND NORTH WALES.

PART I.—WEST SHROPSHIRE, BY BERNARD
SMITH, M.A.

PART II.—NORTH WALES, BY HENRY DEWEY
AND BERNARD SMITH, M.A.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



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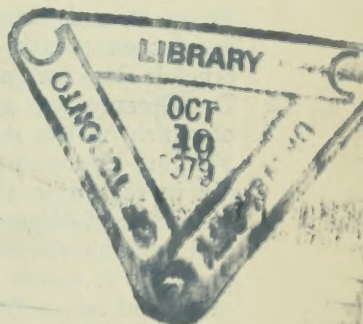
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PREFACE.

The lead and zinc deposits described in this memoir include a number which have not been worked of recent years and about which not much information is available; others have been actively exploited in the last decennium and were the subject of investigation, especially during the war. The officers of the Geological Survey who have written this memoir have received much assistance and information from those in charge of the mines, and desire to express their indebtedness, especially to Lieut.-Colonel J. V. Ramsden of the Shropshire Mines, Ltd., who supplied them with copies of the plans of this Company's mines on the scale of twenty-five inches to one mile. A valuable report on this property by Mr. T. C. F. Hall, M.I.M.M., was also placed at our disposal by Lieut.-Colonel Ramsden, who allowed us to make free use of the information it contained. Professor Lapworth's manuscript maps of the geology of the Shropshire district are now deposited in the library of the Geological Survey, and have been freely consulted; they are invaluable to students of the older rocks of this province. Captain William Oldfield, of the Snailbeach Mine, has most kindly assisted us in many ways. We are indebted to Mr. H. Watson, of the Berwyn Granite Co., Llangynog, for information about some Montgomeryshire mines. In connection with the mines of Eastern Carnarvonshire, Messrs. Holmes, Little, Froggatt and Evans have been consulted, and their services have been greatly appreciated. We desire also to thank Mr. Sinclair Ross for particulars of lead and zinc mining in Merioneth. Dr. Greenly was consulted regarding the geology of Anglesey, of which he has made a special study for many years, and Mr. Fanning-Evans of the Parys Mountain Mines has given valuable aid in regard to that property. To Mr. G. J. Williams, H.M. Inspector of Mines, we owe a debt of gratitude for his constant and valuable aid both in the field and in the office. Without his guidance it would have been nearly impossible to locate many of the old mines, or to connect former names with existing mines, and his intimate knowledge of the workings rendered easy the otherwise difficult task of reading the old mine plans.

The memoir has been edited by Mr. Cantrill.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.
1st July, 1921.

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LEAD AND ZINC ORES IN THE PRE-CARBONIFEROUS ROCKS OF WEST SHROPSHIRE AND NORTH WALES.

PART I.—WEST SHROPSHIRE.

CHAPTER I.

INTRODUCTION.

HISTORICAL DATA.

The history of lead-mining in West Shropshire¹ dates back to the time of the Romans, who evidently obtained important supplies of lead-ore from outcrop-workings and shallow levels. The Roman Vein, for example, of the Roman Gravels Mine (p. 16) is said to have been worked to more than 100 yards in depth by the Romans, whose mining-utensils have been occasionally found in the galleries.² When first discovered it is probable that the lead-ore was exposed in ridges down the hill-sides, for even now the silicious contents of some of the veins can be traced along the surface; and at the Grit Mines the Rider Vein forms a projecting wall for several yards.³ Besides mining-implements, coins and pottery have been found. A Roman pig of lead was discovered some years ago at the bottom of the trench along the Roman Vein, together with curious wooden spades, and candles with hempen wicks.⁴ The pig bore the impress IMP. ADRIANI. AUG. Two other pigs also bearing the inscription of the Emperor Hadrian (A.D. 117–138) have been found in this district: one at Snailbeach, now in the British Museum, the other at Snead, now in the Mayer Collection, Liverpool Museum. The Sawpit and Second North Veins of the Roman Gravels Mine were also deeply trenched in those days.

The old excavations were probably enlarged by later miners before recourse was had to deep mining. During the 12th and

¹ The district is contained in the following sheets of the New Series One-inch Ordnance Map: 151 (Welshpool), 152 (Shrewsbury), 165 (Montgomery). The Old Series One-inch Geological Maps concerned are 60 N.E., 60 S.E., and 61 N.W.

² Murchison, 'Silurian System,' 1839, p. 279.

³ G. H. Morton, 'The Geology and Mineral Veins of the Country around Shelve, Shropshire.' *Proc. Liverp. Geol. Soc.*, Session 1868–9; separately printed, 1869, p. 23.

⁴ 'Silurian System,' 1839, p. 279, Note 1, and Morton, *op. cit.*, p. 23.

13th centuries lead was obtained in abundance from this area. The slag-heaps left by these old workers near the Tankerville Arms at Hope, near the Roman Gravels Mine, and at the East Grit Mine, still contain a quantity of lead.¹

The deeper mining with its attendant pumping and the use of blasting-charges and mechanical drills is of comparatively recent date, but records are almost unprocurable. The Gravels and Grit Mines, Snailbeach, Pennerley, and Bog, were all productive in Murchison's day (*circa* 1832-9). The earliest official statistics (1845) show that Snailbeach was then an important producer of lead-ore. The only other productive mines mentioned at that date are Bog, 'Grits and Gravels,' and Pennerley. At a later period Roman Gravels became a considerable producer; but the history of this mine, like that of several others, shows a declining output and final cessation. Subsequent reopening does not appear to have been rewarded with satisfactory results. The last important mine to close as a lead-producer is Snailbeach. Towards their latter days many of the mines showed an increasing output of zinc-ore, first recorded in 1858, and of barytes, first recorded in 1860.

Under the Shropshire Mines Ltd. developments are now proceeding that may restore the field to some of its former importance as a producer of lead and zinc ores.

GEOLOGY.

The lead and zinc mines of the Minsterley and Shelve districts of Shropshire (Fig. 1, p. 4) lie to the south of Minsterley, chiefly in an area of Lower Ordovician (Arenig) rocks bordering the western flank of the Pre-Cambrian uplands of the Longmynd.

On their western margin the Longmyndian rocks are faulted against a strip of Cambrian shales, ranging north-north-east and south-south-west, which are succeeded westward by the Ordovician rocks with an almost similar strike.

The Ordovician rocks, which on the Old Series Geological Map, Sheet 60 S.E., are referred to the Llandeilo Series, were divided by Prof. C. Lapworth² into (1), an Upper or Chirbury Series, of Bala-Caradoc age; (2), a Middle or Middleton Series, of Llandeilo age; and (3), a Lower or Shelve Series, of Arenig

¹ G. H. Morton, *op. cit.*, p. 29.

² 'Summary of Progress' for 1915 (*Mem. Geol. Surv.*), 1916, pp. 36-38. See also Lapworth and Watts in 'The Geology of South Shropshire,' *Proc. Geol. Assoc.*, vol. xiii (1893-4), p. 297.

The late Prof. Lapworth's six-inch MSS map of the Shelve District is deposited in the Library of the Geological Survey and Museum, and is now available for reference.

The mining-area has been mapped and reported upon recently by Mr. T. C. F. Hall, M.I.M.M., for the Shropshire Mines, Ltd. We are greatly indebted to the Directors of this Company for the unrestricted use of his map and report, and for access to numerous plans and notes in their possession; while passages from Mr. Hall's report are incorporated with little or no change in the present volume.

age. It is in the latter that the chief occurrences of ore have been found. The rock-sequence, as far as it concerns the present subject, is as follows, in descending order :—

| | | |
|------------|---|---|
| Silurian | - | Upper Llandovery Series. |
| | | <i>Unconformity.</i> |
| Ordovician | { | Chirbury Series. |
| | | Middleton Series, with Weston Grits and Shales at base. |
| | { | Shelve Series |
| | | - |
| | | - |
| | | - |
| | | Upper Stapeley Ashes. |
| | | Stapeley Ashes and Shales. |
| | | Hope Shales. |
| | | Mytton Beds. |
| | | Stiperstones Quartzite. |
| Cambrian | - | Tremadoc, Shineton Group, Habberley Shales. |

The physical features of the district are closely related to the geological structure, the more resistant beds forming lines of hill and scarp, while the softer beds underlie the valleys and the low ground (Fig. 2, p. 10)¹.

The Ordovician beds, despite the fact that they show complexities in detail, possess a comparatively simple geological structure, dipping west-north-westward off the Cambrian shales, which they succeed conformably. The Lower Ordovician rocks, however, are repeated by the occurrence of an anticlinal fold (the Shelve Anticline), which brings the Hope Shales and Mytton Beds to the surface in the west, after they have sunk beneath a syncline (the Buxton Syncline) in which relics of the Stapeley Ashes occur as isolated outliers. Shelve and Hope are both situated on this anticline, west of which the beds succeed one another in orderly sequence west-north-westward. The result is that the Mytton Beds in particular occur in two outcrops, the eastern having a west-north-westward dip off the Stiperstones and beneath the Hope Shales, the western forming an anticline with fairly steep-dipping flanks and a north-north-eastward pitch.

The Ordovician rocks were subjected to these movements and denuded before the deposition of the Silurian rocks, which cross their outcrops unconformably. Outliers of the Silurian in the synclinal area, however, suggest that these movements were repeated, to a less extent, at a later date.

Intrusive rocks occur as laccolites, sills and dykes of basic composition, namely dolerites or diabases. Some of these are intimately related to the structure of the sedimentary rocks, and have risen more or less vertically along strike-faults or lines of weakness produced by strain, or have moved along bedding-planes. They have altered the rocks in their vicinity. These igneous intrusions appear to have been connected, perhaps as an aftermath, with the disturbances that preceded the deposition of the overlying unconformable Silurian beds. They are closely related in composition to the contemporaneous Ordovician lavas and ashes.

A second period of intrusion seems to be represented by more regular and relatively narrow dykes, which traverse the

¹ Fig. 2 is after T. C. F. Hall.

strata at a high angle on approximately north-westward and east-north-eastward lines. These are quite independent of the above-mentioned structures, and cut across the folds and fractures due to the pre-Silurian movement. In their mode of occurrence they often bear a close resemblance to the mineral veins. Here and there, both veins and dykes are in contact for long distances, in which circumstances the dyke-rocks appear to have undergone alteration to a micaceous substance (sericitization), and are referred to as 'white rock' and 'rider.' The inference is that the dykes are of earlier date than the mineral veins¹, and occupied the fissures prior to their invasion by the metalliferous solutions. They are probably of Silurian or post-Silurian age.

Before discussing the faults and ore-bearing veins, we may refer briefly to the character of some of the sediments.

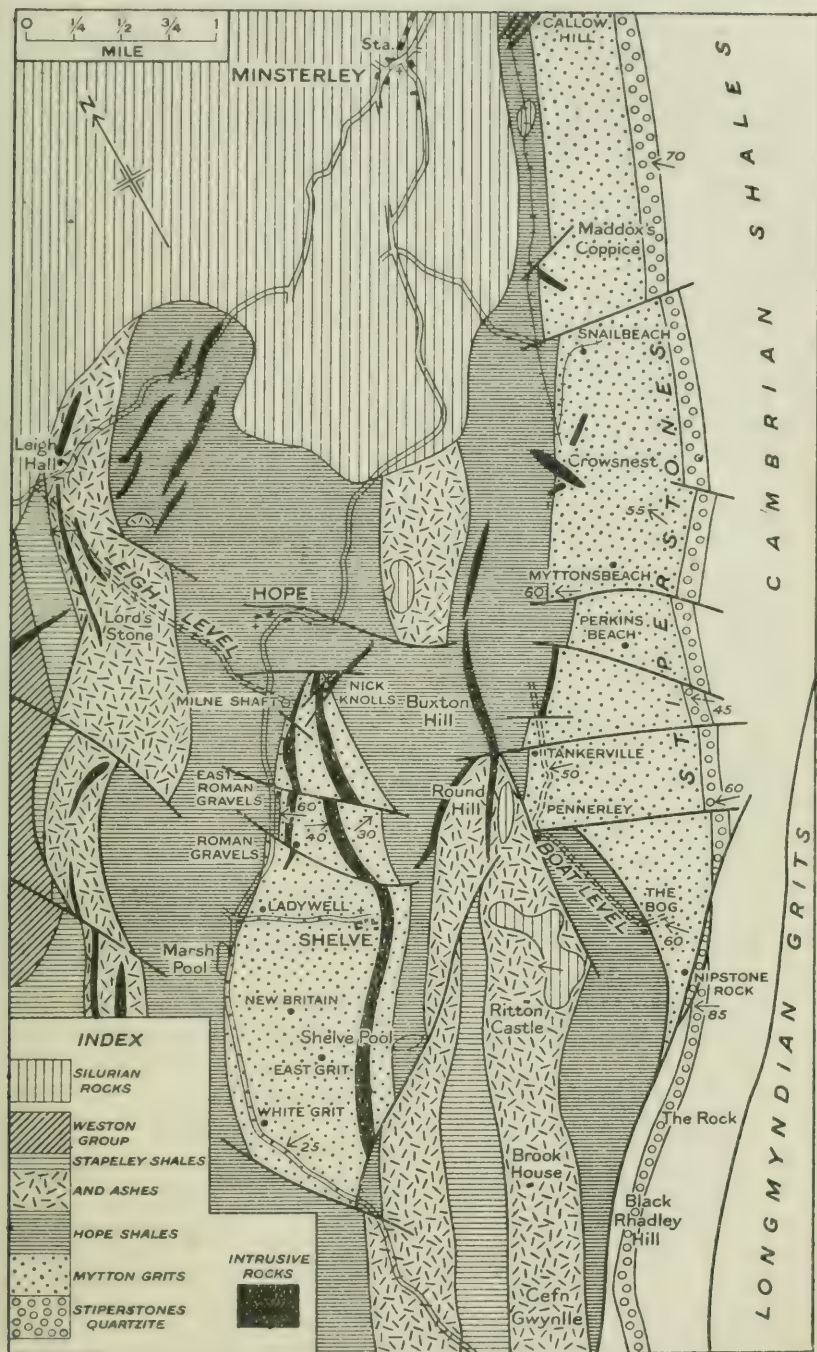
Stiperstones Quartzite.—This is, in the main, a well-bedded silicious sandstone or quartzite, forming pronounced ridges and crags, and varying in dip from 45° to 75°. By folding it should approach the surface again beneath Shelve Hill, where its depth is estimated to be 1,200 ft. The upper part is thin-bedded and interlaminated with bands of flagstone, and passes upwards into the Mytton Beds.

Mytton Beds.—These consist chiefly of massive bands of hard dark grit alternating with flaggy shales, and are often recognisable by the well-marked banded or ribbed structure of the grits. The shaly material becomes more and more predominant upward, till the subdivision finally merges into the succeeding Hope Shales. Lapworth divides the Mytton Beds in descending order as follows: Tankerville Flags and Shales; Gravels and Shelve Church Beds; Ladywell and Snailbeach Grits (Flags) and Shales; Lord's Hill Beds. Although on strictly geological and palæontological grounds the transitional beds—the Tankerville Flags and Shales—are included with the Mytton Beds as Lower Arenig, from the mining point of view they would more suitably be incorporated with the Hope Shales, and in the following account they are frequently referred to this group.² The Mytton Beds form high ground and attain their maximum development about the centre of the area, being narrower to the north and thinning away to the south, where they are largely cut out by strike-faults. Folding brings them to the surface again in the anticline of Shelve Hill. The principal mines of the district are situated in these rocks.

Hope Shales.—These are soft black shale-beds, which cover a large area and form the greater part of the low ground. In places they contain bands of volcanic ash and are often crumpled and folded in detail. They are barren of ores, and represent the

¹ Morton, *op. cit.*, pp. 30, 32.

² T. C. F. Hall, 'Report on the Shropshire Mining District,' *London*, 1919, p. 13. (Privately printed.)



GEOLOGICAL SKETCH MAP OF
MINSTERLEY - SHELVE DISTRICT.

Middle Arenig, but some Lower Arenig Beds, as above mentioned, are included, from the point of view of the mining man.

Stapeley Ashes.—These beds, which succeed the Hope Shales, are fine-grained volcanic ashes, and volcanic grits and breccias interbedded with shales; they represent the Upper Arenig.

FAULTS AND VEINS.

FAULTS.

The Ordovician rocks are traversed by numerous faults, which can be grouped in two sets :—(a). In one set the fractures trend chiefly north-eastward or north-westward, a marked exception being the north-and-south fault that extends from Round Hill to the neighbourhood of the Bog Mine.

(b). In a second set the fractures, with little or no relative displacement of the walls, have a direction a little north of east and south of west. They are of considerable importance in that they are extensively mineralized.

Whilst some of the first set—such as those with the north-north-east direction, which are strike-faults—are evidently connected with the disturbances that antedated the deposition of the Silurian strata, there is reason to believe that much of the faulting in other directions is of post-Silurian date,¹ and is connected with the earth-movements that so profoundly affected this part of the country in late Silurian and early Devonian times. In the result two sets of fractures cross each other at a high angle—a type of fracturing due to compression, and well recognised in many mining districts. The two sets must have been formed almost concurrently, and they intersect, in places, without relative displacement. In general the north-westerly fissures, which break across the pre-Silurian folds, are readily recognised by the abrupt termination of the strata against them, while east-north-east fissures, as stated above, show little relative displacement of the walls.¹

Since no case has been recorded in which a vein filling a fracture of displacement is faulted out, we may assume that the movements took place previous to mineralization.

The majority of the faults hade in a southerly direction, though many incline to the north. Where two or more parallel fissures hade towards each other, the intervening trough of ground is usually much disturbed and fractured.

The faults are best developed in the harder beds such as the Mytton Grits and Stapeley Ashes, and tend to die out and lose their individuality in the soft shales, where the fissures become filled with a tight 'pug' of crushed material. To this fact we must attribute the barrenness of fractures in these soft beds.

¹ Hall, *op. cit.*, p. 16.

VEINS.

The mineral veins¹, many of which are shown on the Old Series One-inch Geological Map, 60 S.E., obviously occupy fissures, which served as channels for the circulation of ore-bearing solutions derived from some deep-seated igneous source. They show, however, no connexion with any of the exposed igneous intrusions; probably they are related to a concealed mass of granite. The main veins appear to occupy fault-fissures, although this cannot be demonstrated in every case. Doubtless they have experienced movement at more than one date, but although the frequent brecciation of their contents points to disturbance after mineralization, they have not suffered the complex sequence of repeated fracturing and mineralization that took place in the Cornish lodes. The mineralization may be regarded as a single episode. Moreover, it is unlikely that fissuring and mineralization are widely separated in time.²

Whilst the fractures themselves may extend for a great distance continuously through rocks of several types, it must be strongly emphasized that the ore-bodies are discontinuous, and their presence or absence is intimately related to the physical³ character of the country-rock. A parallel case is the mode of occurrence of the ores in the Llangynog district of Montgomeryshire. In certain kinds of rock—in Shropshire typically represented by the Mytton Grits, at Llangynog by the igneous rocks, and in Flintshire by the massive Carboniferous limestones and cherts—well-defined open fissures, capable of mineralization by circulating waters, are formed; in other rocks, such as the Hope Shales, as explained above—or the Holywell Shales in Flintshire—the walls of the fissures close tightly together. The general effect is relative; rocks suitable as ore-bearers in one district may be comparatively barren in another. Again, in the Mytton Beds themselves, the ore frequently occurs as ‘shoots’ or ‘floors’⁴ in the gritty strata, but is relatively deficient in the interbedded shaly bands.

It is said by the miners that when the veins are traced into the Stiperstones Quartzite they become impoverished or barren, and this receives support from other districts, such as Flintshire and Denbighshire, where veins traced into the sandy part of the Cefn-y-fedw Sandstone appear to pinch out and become unprofitable. In the flaggy top of the Stiperstones, however, ore occurs, here and there, along the bedding-planes, and this has

¹ In the present volume the terms ‘vein’ and ‘lode’ are used synonymously. No difference of meaning is implied.

² Hall, *op. cit.*, p. 21.

³ A. M. Finlayson, ‘Problems of Ore-Deposition in the Lead and Zinc Veins of Great Britain.’ *Quart. Journ. Geol. Soc.*, vol. lxvi, 1910, p. 299; *vide* pp. 322, 323. This author shows that in carbonate rocks (limestones and dolomites) the chemical character of the rock also may have considerable influence.

⁴ D. C. Davies, ‘Metalliferous Minerals and Mining,’ ed. 2, 8vo., *Lond.*, 1881, pp. 202–3.

been found to be the case in some of the other rocks also, where differential movement of the strata has left cavities near fault-lines. The infilling deposits are of the nature of flats.

The more important veins have two main trends, corresponding with the main lines of fissuring that influenced the flow of the ore-bearing solutions: (1), N.W. and S.E.; and (2), E.N.E. and W.S.W., the latter approximating to east and west.

On the whole the solutions seem to have selected chiefly the east-north-east fissures for their passage, and many of the largest veins in the district are of this trend, possibly because the north-west fractures, by their greater movement, were less easily negotiated. Thus a number of north-west and south-east faults in the main outcrop of the Mytton Beds are barren. In the Shelfe Anticline, however, this is not entirely the case. The ideal conditions for maximum deposition of ore occurred at the junction of two fissures, as at the Tankerville and Bog Mines.

As far as can be ascertained, the order in which the rising mineral solutions deposited their contents is as follows: copper-ore, zinc-ore, and lead-ore, and compounds of barium and fluorine. The main zone of copper-deposition appears to have lain in the deep-seated Pre-Cambrian rocks, while the deposition of zinc-ore, lead-ore, and barytes took place in the Ordovician belt above.¹ But while this is the general arrangement, we may note that copper pyrites occurs sporadically in the gangue of the lead-veins, as at Tankerville, that at Rorrington the east-and-west veins carry lead above barytes, and that lead occurs occasionally, as at Wrentnall, in the Pre-Cambrian copper-zone. The barytes in the Pre-Cambrian rocks is considered to be secondary.

No ore-deposition took place in the Cambrian shales. In the succeeding Ordovician rocks the solutions seem to have been checked by the Hope Shales, and mineralized the Mytton Beds; such solutions as penetrated above the Hope Shales appear to have carried barium with subordinate amounts of lead. The vertical range of the ore-bearing Mytton Beds, where they dip most steeply, is about 2,000 feet, within which compass shoots of ore² may be expected to occur, especially in the gritty beds beneath the base of the Hope Shales. Barytes usually forms a capping to the veins, and in depth gives place to lead, which in turn will be likely to give place downwards to zinc.

The gangue consists chiefly of crushed country-rock with quartz and calc-spar, often in large and well-formed crystals, as at Snailbeach and Tankerville. The gangue often contains barytes and occasionally pyrites and fluorspar. In most of the lodes

¹ Hall, *op. cit.*, p. 23.

² The preference of shoots of ore for certain suitable beds traversed by a long fracture in inclined strata is well shown in the case of some of the veins in the Carboniferous Limestone Series of Flintshire. See 'Special Reports on Mineral Resources' (*Mem. Geol. Surv.*), vol. xix, Pl. III.

the galena and blende lie in irregular strings, which here and there open out into nests of ore.

ANALYSES AND ASSAYS.

The amount of silver occurring with the galena is small, even when compared with that obtained from the ores in the Carboniferous rocks of Flintshire and Denbighshire, in which the silver-content is comparatively low. No values for silver have been returned in the official Statistics since 1883; the figures given below are the average returns for the final two years. In the Table the percentages of lead and zinc are the extremes met with during such periods as the mines were in work between 1882 and 1913.

Assays of Shropshire Lead and Zinc Ores.

| Mine. | Percentage of Lead in Ore 1882-1913 | Percentage of Zinc in Ore 1882-1913 | Silver: oz. per ton of lead-ore 1882-1883 |
|--------------------------------|---|---|---|
| Snailbeach - | 77-84·5 | 42-58 | 0·5 |
| Perkins Beach - | 70-79 | nil | not given |
| Tankerville - | 79-83 | 40-52·5 | 2·0 |
| Roundhill - | 80 ¹ | nil | mine not working |
| Pennerley - | 75-80 | 45-50 | 2·0 |
| Bog - | 79-81 | 40-59 | 2·16 |
| Rhadley and Rock East Roman | 65-80 ² | nil | mine not working |
| Gravels - | 75-85 | 40-58 | 2·5 |
| Roman Gravels - | 80-82 | 40-56 | 2·23 |
| Grit - | 72-73 ³ | 48 | mine not working |

¹ In 1907.

² In 1888, 1907-8.

³ In 1898-1901.

The assays given below are of galena and blende raised in recent years by the Shropshire Mines Ltd. from the veins in the Bog Mines area.

Analysis of Galena from the Nipstone Vein (Bog Mines).

Analysts: Messrs. W. F. & H. Lowe, Chester, 9 July 1919. Ore dried at 100° C.

| | | | | | | | | | |
|-----------------------------|---|---|---|---|---|---|---|---|-------|
| Lead - | - | - | - | - | - | - | - | - | 82·93 |
| Copper - | - | - | - | - | - | - | - | - | 0·52 |
| Zinc - | - | - | - | - | - | - | - | - | 0·12 |
| Iron - | - | - | - | - | - | - | - | - | 0·07 |
| Sulphur - | - | - | - | - | - | - | - | - | 11·07 |
| Silica - | - | - | - | - | - | - | - | - | 0·70 |
| Calcium oxide - | - | - | - | - | - | - | - | - | 0·75 |
| Alumina - | - | - | - | - | - | - | - | - | 0·05 |
| Barium sulphate - | - | - | - | - | - | - | - | - | 1·45 |
| Tin - | - | - | - | - | - | - | - | - | 0·08 |
| Carbon dioxide (by diff.) - | - | - | - | - | - | - | - | - | 2·26 |

100·00

Silver: 2 ozs. 5 dwts. per ton of ore.

Analyses of Blende from the Bog Mines area.

Analysts: Messrs. W. F. & H. Lowe, Chester. Ore dried at 100° C.

| | No. 1. | No. 2. | No. 3. | Bog. |
|--|--------|--------|--------|--------|
| Lead - - - - | 1·67 | 1·60 | 4·40 | 3·78 |
| Copper - - - - | 0·78 | 0·25 | 0·28 | 0·10 |
| Zinc - - - - | 50·25 | 39·54 | 39·97 | 52·07 |
| Iron - - - - | 2·92 | 2·10 | 3·15 | 3·16 |
| Alumina - - - - | — | — | 0·95 | 0·30 |
| Lime - - - - | 0·25 | 0·35 | 0·50 | 1·25 |
| Magnesia - - - - | 0·10 | 0·10 | 0·05 | 0·15 |
| Sulphur - - - - | 27·58 | 21·49 | 22·29 | 23·89 |
| Insoluble residue:— | | | | |
| Barium sulphate - - | 8·65 | 27·50 | 16·85 | 6·88 |
| Silica - - - - | 6·95 | 5·38 | 8·97 | 8·45 |
| Ferric oxide, alumina, and lime - - - - | 0·98 | 1·60 | 2·62 | 0·43 |
| | 100·13 | 99·91 | 100·03 | 100·46 |

All the samples were free from fluorine.

OUTPUT.

Fig. 13 gives in a graphical form the outputs of lead and zinc ore for Shropshire since 1845, and the outputs of lead and zinc ore from some of the chief mines. The highest recorded output of dressed lead-ore for the whole country was for 1856. At that date nine mines were operating in Shropshire, and yielded 4,407 tons 19 cwts. of dressed ore, giving 3,228 tons 15 cwts. of metallic lead. The production in Shropshire rose to its height between 1871 and 1875, since which date it has declined, first rapidly, and then steadily, to the present day. In 1916 only two mines were operating, and yielded but 32 tons of lead-ore; and at the present day only a small quantity is obtained, chiefly from the Bog group.

The output of Snailbeach is the most important, but shows on the whole a steady decline. The maximum for the district was attained when Gravels, Ovenpipe (Tankerville), Bog and Pennerley added their maxima to the Snailbeach output.

The highest recorded output of zinc-ore for the whole country was for 1881. In this year four Shropshire mines were operating, and yielded 197 tons of ore, giving 107 tons of metallic zinc; but the following year gave the maximum for the county, viz., 914 tons of ore. This figure was nearly reached again in 1897, when 880 tons were got. Of late years the output of zinc-ore has become relatively more important, and from 1911 to 1914 was greater than that of the galena.

Further details of output will be found under the detailed descriptions of mines in the following chapters.

RECENT DEVELOPMENTS.

The old mines were unwatered by pumping from the deep levels, and also by several long adits, such as the Wood Level in the Shelve Anticline, and the Boat Level in the Tankerville-Bog district, as well as others of shorter length described under the details of mines (Chap. II.).

An extensive scheme, intended to unwater, by a day-adit, the large group of mines situated on the western side of the Shelve Anticline, is now being actively pushed forward by the Shropshire Mines Ltd.

The adit known as the Leigh Level (Fig. 2, p. 10) was commenced many years ago by farmer adventurers. In or about the year 1820 a drainage company (known locally as the Farmers' Company) was formed with a capital of £39,000 to drive a deep drainage-tunnel called the Dingle or Leigh Level, with the intention of draining all the Shelve mines. The tunnel was commenced in 1825; but, after being driven nearly $1\frac{1}{4}$ miles (actually 5,932 feet), it was abandoned in 1835, owing to shortage of money following upon lawsuits with Lord Tankerville.¹ The level commences² in Brookless Coppice, about 250 yards west of Leigh Hall, and $2\frac{1}{2}$ miles west-south-west of Minsterley, at a height of about 380 feet O.D., and runs generally in a south-south-east direction (Figs. 2 and 3, pp. 10 and 14).

There are four shafts upon this first section, the one nearest the forebreast being about 1 chain from Lord's Stone in Lord's Stone Lane. Farther north is the Blue Barn Shaft, about 130 yards south of Blue Barn Cottage and 1,110 yards from tunnel mouth. The tunnel was about 7 feet high and 5 feet wide and had been driven in dead ground.

On a plan, with section, of the Rev. J. More's property, dated 1869, a scheme is figured for continuing the tunnel to the Roman Gravels shaft, and thence southward to East Grit Old Engine Shaft.

Recently the Shropshire Mines Ltd. determined to extend the tunnel, and operations were commenced simultaneously from Blue Barn Shaft and the new Milne Shaft,³ situated about 700 yards south of Hope Church, and 100 yards north of the old Batholes shaft.

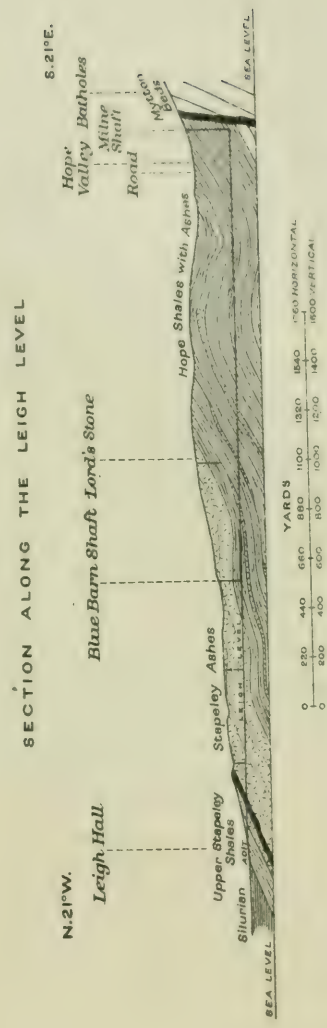
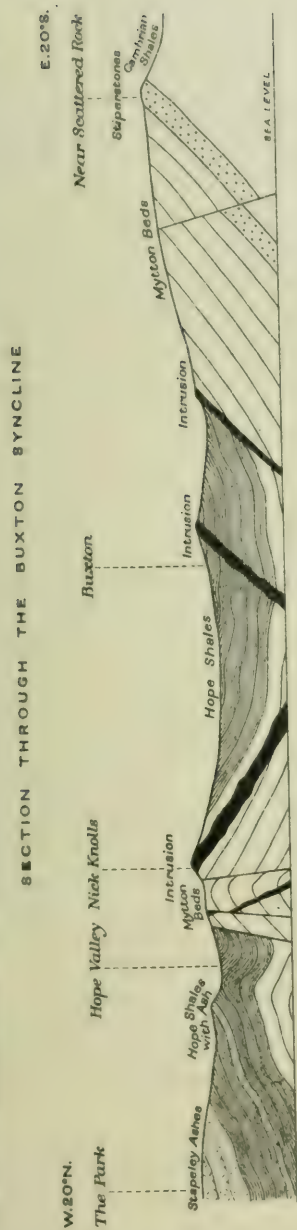
The Blue Barn Shaft is 260·7 feet deep, and the bottom at tunnel-level is 399 feet O.D. The distance between the Blue Barn Shaft and the Milne Shaft, measured along the tunnel, which has several bends, is 2,002 yards, in which distance the level rises by 14 feet to 413 feet O.D. The Milne Shaft is 527·9 feet deep, going down to 397 feet O.D., its top being

¹ For section of the beds passed through in this portion, see 'Silurian System, 1839, p. 281, Note 1.

² Six-inch map, Shropshire 47 N.E. Lat. $52^{\circ} 37' 29''$, long. $2^{\circ} 59' 19''$. The figures for the latitudes and longitudes given in the present volume are taken from the six-inch maps.

³ Six-inch map, Shropshire 47 N.E. Lat. $52^{\circ} 36' 3''$, long. $2^{\circ} 58' 28''$.

Fig. 2.



SECTION THROUGH THE BUXTON SYNCLINE AND ALONG THE LEIGH LEVEL.

at 925.06 feet O.D. It is a bricked circular shaft of 14 feet diameter, and will form the chief centre of mining operations, if the driving is successful. At the time of our visit, in Oct. 1919, it was being fitted with cages. The section of the tunnel between the Blue Barn Shaft and the Milne Shaft was completed in Sept. 1919, and the tunnel is now being driven south-westward in the direction of the Wood Engine Shaft of the East Roman Gravels Mine, which it will enter at 100 feet below the shaft-bottom, at a point where the Cornish or California and Wood Lodes are supposed to intersect by opposed dip (Fig. 3). By 4th Nov. 1920 about 2,028 feet of this section had been driven through shale, greenstone and Mytton Beds, the total distance from the Milne Shaft to the Wood Shaft being about 820 yards. Thus the length of the tunnel from the mouth to the Wood Shaft is over 3,932 yards. About $1\frac{1}{2}$ miles of further tunnelling would carry it to the Grit Mine. The tools employed have been compressed air Climax and Ingersoll Rand drills, the average rate of driving being about 300 feet a month. The air-compressor is also used for ventilating.

The hope entertained that this adit would, in the course of driving, open up a large extent of productive ground has not been fulfilled, and could hardly be justified either on geological grounds or from local mining experience, for the ground traversed up to the Milne Shaft is chiefly Stapeley Ash and Hope Shales—well above the usual ore-bearing horizon of the Mytton Beds (Fig. 2, p. 10). Now that the tunnel is in the ore-bearing beds, it remains to be seen whether the veins it will unwater below the old mine-workings can be made to pay, and whether the new veins cut are productive.

In some cases, again, the level reached by this adit in some of the old mines will be well above that attained by the old workings (pp. 16, 17); hence pumping-charges will be added to the capital charges of the undertaking. Since, however, the water is chiefly descending surface-water these costs should not be great. There is no large reservoir of water with a well-marked water-table, like that occurring in many limestone districts.

If a branch from the level were driven from the Hope Valley to the Bog Mine in the eastern outcrop of the Mytton Beds, it would penetrate these beds in the Shelve Anticline also, but only at a level that has already been opened up and worked. Beyond this anticline the greater part of its course would be in the Hope Shales.

The future of the district is, therefore, at the moment of writing, in suspense, owing chiefly to the want of knowledge of the true state of the water-logged mines. The tunnel will drain an immense area to a depth of 800 to 1,300 feet from the surface, according to the profile of the ground. Modern plant, together with mining-knowledge and practice, backed by sound geological advice, may produce satisfactory results even in the case of mines that were abandoned through the apparent poorness of

the veins. Whilst there seems good reason for the belief that most of the better-known veins have already yielded the greater part of their lead-ore, a much greater future production of zinc-ore may be expected, since, in some cases, considerable quantities of exposed ore remain, while in others deeper mining should bring rich deposits to light. It might pay to work lead-ore in mines that are rich in both barytes and blende.

Since the Mytton Beds are the chief carriers of ore in the district, it has been suggested¹ that capital might be expended profitably in exploring these beds beneath their cover of Hope Shales in the centre of the syncline that separates the two outcrops to the east of the Hope Valley. There is reason to suppose that this virgin ground may prove as productive as that already opened up. North of the Roundhill Mine a shaft sunk through the Hope Shales should enter the Mytton Beds at about 1,000 feet (Fig 2, p. 10).

¹ By Mr. T. C. F. Hall.

CHAPTER II.

SHROPSHIRE MINES.

WESTERN AREA : HOPE-SHELVE DISTRICT.

In this area the Mytton Beds include two outcrops of thick intrusive igneous rock, that on the east behaving as a sill, that on the west as a dyke, oblique to the bedding. At the northern end of the anticline the two outcrops of this rock come close together, the actual nose of the anticline being cut off and dropped by a fault trending west-north-west and east-south-east. On the west side the Mytton Beds dip W.N.W. or N.W. at 60° or more, and the intrusion on this side dies out south of the Roman Gravels Mine, where the dip of the Mytton Beds is lessened, and the dyke-like intrusion is oblique to their bedding-planes. On the east side the inclination of the beds varies from 30° to 60° , and the intrusive sheet persists throughout.

The mines and veins will, with few exceptions, be taken in geographical order from north to south. The new Milne Shaft¹ provides a convenient fixed point of reference, 700 yards south of Hope Church, and 150 yards south-east of the main road in the Hope Valley.

Nick Knolls Mine.—This is situated on the southern of two faults displacing the intrusive rock and trending south-west and north-east across the eastern limb of the Shelve Anticline. The shaft (985·37 feet O.D.) lies 370 yards east of the Milne Shaft. The inclination of this vein, which appears to be duplicated, is south-eastward at about 60° . From a point a few yards south-west of the shaft a short adit, No. 1, has been driven transversely to the vein through the hill at 997·78 feet O.D. To the north a second adit, No. 2, at 966·34 feet O.D. has been driven longitudinally and apparently along what is known as the Big Vein, the northern of the two above-mentioned faults, which is a downthrow north-westward; this adit is possibly on the 'Nick Knolls Vein' mentioned on an old mining-plan and section, dated 1844, and preserved in the office of the Shropshire Mines Ltd. The vein reaches 8 to 9 feet in thickness, but frequently is 'pinched.'

The levels were driven for barytes, but No. 1 shows promising traces of galena. In the igneous rock the vein is cut out.

Batholes Mine.—This lies 400 yards south-west of Nick Knolls, on the axis of the anticline. The shaft (963·77 feet O.D.) is at the western foot of the steep slope formed by the intrusive rock, 100 yards south of the Milne Shaft. The lode trends north-by-west, and underlies eastward at about 55° from the horizontal. The shaft is about 60 feet deep and goes down only to the adit,

¹ See p. 10, note 3.

or Brick-kiln Level, which embouches about 50 yards north-west of the shaft, at 904·1 feet O.D. Southward the adit-level is supposed to cut the Nick Knolls Vein at about 290 yards distance from its mouth. The vein was worked over an area of about 40 fathoms in both length and height. From the adit-level in the mine, and about 110 yards south-south-east of the Batholes Shaft, there is a sump with a gin-ring, by which four lower levels were worked. The higher part of the mine was reached by a day-adit driven into the hill a short distance above and south of the top of the main shaft. Near this spot an old shaft lies buried beneath a dump. The vein has been cut recently by the Leigh Level south of the Milne Shaft, appearing as strings of calc-spar with galena and blende intermixed. It was driven upon for 90 yards in a cross-cut from the level.

Murchison notes that near here there is not a sufficient area of sandstone and shale [Mytton Beds] to afford ground for the production of extensive veins, the bosses of greenstone that form part of the nucleus of the ridge of Nick Knolls and Santley Hill rising nearly up to the edge of the little valley. Further, that veins frequently reappear on the opposite side of the intruded rock, which is itself sterile. None of the mineral veins has been found to penetrate trap rock of intrusive character.¹

The mine produced galena at fairly frequent intervals up to 1867, since which date only a few tons have been got.

To the south-west of Batholes are several small and little-known shafts, the next vein of any note being the *Gate Level Vein*, trending north-west and underlying north-east. The shaft, which is about 60 yards east of the high-road², was 22 fathoms deep. Immediately south of this vein the famous Wood Drainage-Level commences its southerly course by devious routes through the Gravels and other mines to the East Grit Mine, a total distance of about 1½ miles. Its embouchure³ is at 865·27 feet O.D., on the Hope Valley brook, 640 yards south-west of the Milne Shaft. The level runs 210 yards south-eastward to the old Black Gin Shaft,⁴ 20 fathoms deep, where it turns south-westward to cross-cut and drain the numerous lodes encountered to the south. In some parts its straight course is interrupted and diverted along a lode as a level for some distance before its resumption as a true cross-measure drift. This is probably due to the late and sectional linking up of isolated mines by the level between shafts already established.

East Roman Gravels Mine.—The chief veins in this mine⁵, which lies approximately half a mile south-south-west of the Milne Shaft, are the Wood Lode, the Cornish and Caunter (or Counter) Lodes, and the California Lode (Fig. 4, p. 16). The

¹ 'Silurian System,' 1839, pp. 279, 280.

² On the southern edge of the six-inch map, 47 N.E.

³ Six-inch map, Shropshire 47 N.E. Lat. 52° 35' 52", long. 2° 58' 53".

⁴ Shropshire 47 S.E. Surface, 956·85 ft. above O.D.

⁵ Shropshire 47 S.E.

Wood Lode corresponds in position and direction of hade with a fault that breaks across the anticline and displaces the strata. The intrusive rock is here inclined in the opposite direction to the Mytton Beds, which dip W.N.W. at 60°, and it therefore suffers a displacement in the opposite direction to that of the sedimentary rocks. The Wood Vein (Fig. 5, p. 18) trends north-westward, underlies south-west at 66° from the horizontal, and has been worked to the 60-fathom level from outcrop, the chief levels from the Wood Shaft being at 10, 18, 28, 40, 48 and 60 fathoms, measured below the Wood Level, which is 120 feet below the surface (867 feet O.D.). The 18-fathom level is about 260 yards long in stoped ground.

The Wood Shaft¹ (987·39 feet O.D.), 480 feet deep, lies between the Wood and Cornish Lodes, 180 yards south-west of the Black Gin Shaft. Between these two shafts lies the East Roman Gravels Shaft, almost on the outcrop of the Wood Lode. Lawrence's Whim Shaft (1,053·95 feet O.D.) occupies a similar position farther south-east.

The Cornish Lode, about 120 yards south-west of, and parallel to, the Wood Lode at adit level, hades north-eastward, and is nearly vertical. It has been worked from outcrop to the 48-fathom level below adit from the Wood Shaft, but stoped only to the 37-fathom level. Adit-level in the productive part of the lode is 176 yards in length. The Cornish Shaft (1,068·95 feet O.D.), 234 feet deep (adit at 174 feet), almost on the outcrop, is about 110 yards south of the Wood Shaft. Close to it, on the west, is the California Shaft (1074·28 feet O.D.), 270 feet deep.

The California Lode is about 70 yards south-west of the Cornish Lode, trends west-north-west and east-south-east, and underlies northward at about the same inclination as the Wood Lode. It has been worked to some 15 fathoms below the Wood Level, which is 180 feet below the surface at this shaft. It yielded hundreds of tons of galena above the adit-level. It is estimated that the California, Cornish, and Wood Lodes will intersect close to the point at which the Leigh Level will pass beneath the Wood Shaft.

A Caunter Lode, hading northward, has been worked at 48 and 60 fathoms below adit in the southern part of the mine east of the Cornish Shaft.

The mine was closed down in 1901, the blende having hardly been touched. Its recent active life extended from 1869 (when it was known as West Tankerville) to 1901, during which period both galena and blende were raised, with much calc-spar. A few tons of pickings have been got since. Its maximum output of galena was 440 tons in 1881; of blende, 539 tons in 1899. No barytes has been mined. It is generally believed that large quantities of zinc-ore remain to be got.

Roman Gravels Mine.—This lies nearly a quarter of a mile south-west of the East Roman Gravels sett. In this mine

¹ Lat. 52° 35' 43", long. 2° 58' 52".

(Fig. 3, p. 14) there are five principal veins : Roman, Caunter or First North, Second North, Sawpit, and Spring Veins. The Roman Vein, half a mile in length and one of the largest in the district, was worked by the Romans: spades, candles, a pig of lead, coins and pottery attributable to them having been found in the workings. They also worked the Sawpit and Second North Veins.¹ The Roman Vein (Fig. 6, p. 20) underlies north-east and trends south-eastward, occupying a fault that displaces the outcrops of the strata, which dip west-north-west at 25° to 45°, the intrusive rock behaving in the same manner as in the Wood Mine. At the north-west end of the mine, near the Old Engine Shaft, the inclination of the vein is approximately 68° from the horizontal, but south-eastward it becomes steeper, and at one point becomes actually reversed for a space, between the 80- and 125-fathom levels. South-eastward it terminates against the Hope Shales.

The Romans worked the vein in a south-eastward direction for 200 yards, their openworks being from 20 to 50 feet in depth on a 2- to 6-foot lode, and they mined it down to 100 yards. Their workings were continued and extended in the 12th and 13th centuries, and in Murchison's time (1839) the mine was being worked at a depth of 112 yards below the Roman galleries.²

The Old Engine Shaft,³ 900 feet deep, situated on the east side of and 30 feet above the main road, about 370 yards west-south-west of the Wood Winding Shaft, is on the main Wood Level (p. 14) at the north-west end of the Roman Vein. East of this point the lode has been worked at levels of 40, 50, 65, 80, 95, 110, 125, 140 and 155 fathoms below the Wood Level, the last-named depth being 200 fathoms from the surface at the New Engine Shaft, or 220 feet below Ordnance Datum. This is about 600 feet below the proposed Leigh Level. In 1860 the vein was being worked at 480 feet below the turnpike road. In depth the vein varies from 6 inches to 10 feet in width, and in the lowest level it was last reported as looking very strong and promising. A vein of felspar connected with the intrusive dolerite was found in the bottom of the mine at 600 feet. Murchison states that a "highly inclined band of compact felspar forms the wall or rider, and as this rises conspicuously above the surface it may have led to the first attempts of the ancient adventurers. The works are distinguished from those of modern date by the smallness of the drifts and the avoiding of those knots of hard rock which now give way before gunpowder."⁴

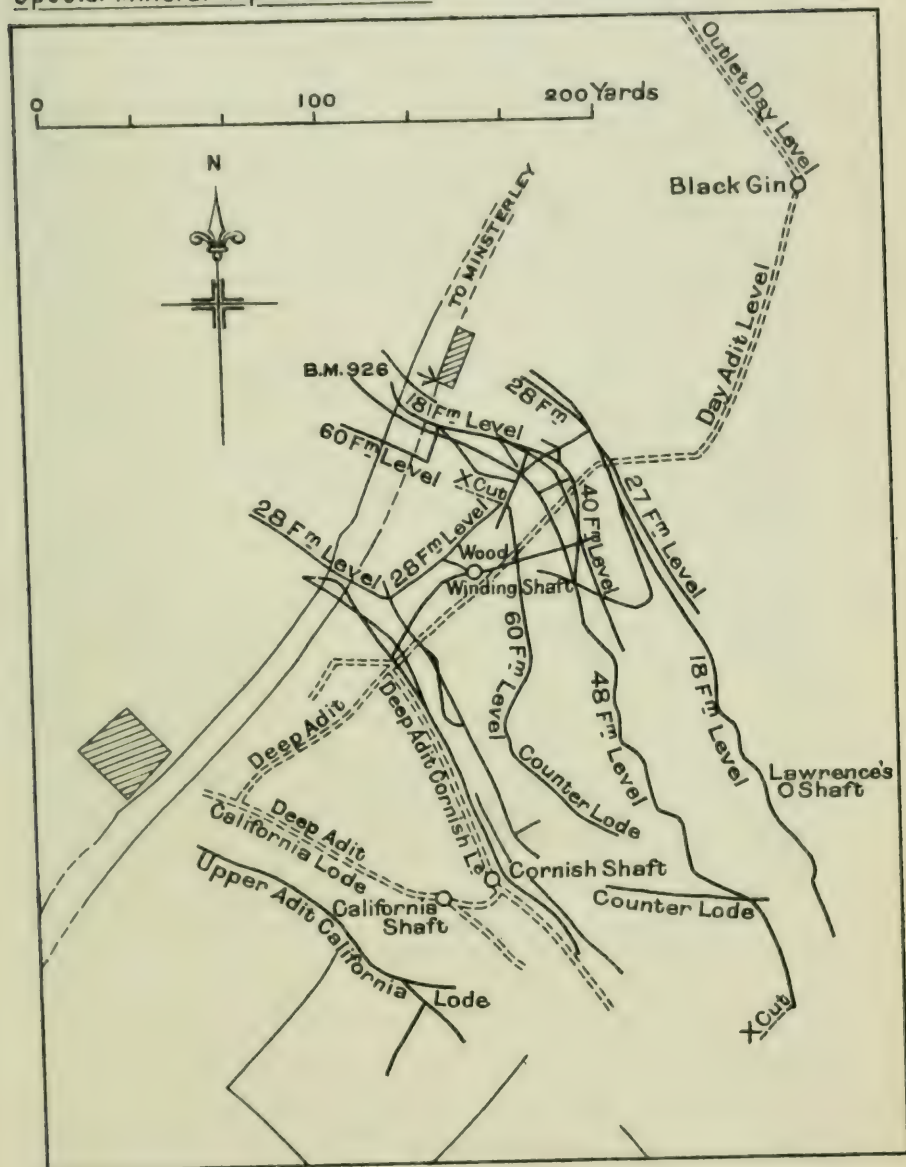
The New Engine Shaft, 1,240 feet deep (Fig. 6, p. 20), lies 170 yards south-east of the old shaft.

¹ G. H. Morton, 'The Geology and Mineral Veins of the Country around Shelve, Shropshire,' *Proc. Liverpool Geol. Soc.*, Session 1868-9; separately printed, 1869, p. 30.

² 'Silurian System,' 1839, p. 279.

³ Lat. 52° 35' 38", long. 2° 59' 0".

⁴ *Op. cit.* p. 279.



PLAN OF THE WOOD MINE SETT.
(EAST ROMAN GRAVELS.)

The Caunter Lode, which we identify with the First North Lode, runs nearly east and west, oblique to, but apparently in contact with, the Roman Vein, and hades steeply southward. It has been worked from the New or main Engine Shaft on the Roman Vein at depths below the 110-fathom level below the Wood Level, down to the 140-fathom level, and from the Boundary Shaft of the East Roman Gravels Mine down to the 109-fathom level. The average length of the levels in productive ground on this lode is from 100 to 120 yards. The Boundary or East Roman Shaft, situated 90 yards east-by-north of the New Engine Shaft, is in the Wood Mine (East Roman Gravels) sett. Its bottom is 110 fathoms below the Wood Level and is connected with Roman Gravels at that depth. The lowest level on the lode is over 346 feet below the bottom of the Milne Shaft on the Leigh Level.

The Second North Lode lies north-east of the Roman Vein on an almost parallel line, and hades north-eastward. It has been worked at the 6- and 20-fathom levels. The Sawpit Vein, which trends east-south-eastward and hades northward, lies to the south-west of the Roman Vein. At adit-level it trends in the direction of the Sun Inn, but has not been explored west of the main Wood Level. The vein has 18 inches of calc-spar, with little ore.

The Spring Vein lies about 230 yards south-west of the Sawpit Vein, with parallel direction but southerly underlie. Spring Vein Pit, on the Wood Level, which here follows the vein for a short distance, was 55 fathoms deep in 1844; it is about 60 yards south-east of the 5th milestone from Minsterley.

The old tip-heaps of these mines contain good samples of galena and blende with pyrites in the gangue of crushed and broken Mytton grits, calc-spar, and quartz. Pseudomorphs after fluorspar, as well as malachite, have been found also. Galena was produced in quantity and continuously from 1859 to 1895 inclusive (Pl. 13, p. 86), 3109 tons being got in 1883. Blende was obtained from 1863 to 1894, the greatest amount being 240 tons in 1891. From 1909 to 1913 a few tons of both types of ore were picked out.

South Roman Gravels Mine lies farther east, and will be dealt with later (p. 22).

The Wood Level was driven south-westward from the Spring Vein Pit through the *Ladywell Mine* to the Ladywell Pit, 280 yards away, cutting a vein known as More's Vein on the way. Ladywell Pit, on the Wood Level, was 32½ fathoms deep in 1844. It is on the Ladywell Vein, which underlies north-eastward and trends north-westward. The deepest workings were 192 feet below adit-level, or 66 fathoms below the surface, a good ore being obtained. At the northern end, where there was a large cavity, the lode was 4 feet wide, with a promising amount of galena.

In this mine three other veins were found. A lode known as the First New Vein (? Caunter Lode) trends about W. 25° N.

The Caunter Lode, which we identify with the First North Lode, runs nearly east and west, oblique to, but apparently in contact with, the Roman Vein, and fades steeply southward. It has been worked from the New or main Engine Shaft on the Roman Vein at depths below the 110 fathom level below the Wood Level, down to the 140-fathom level, and from the Boundary Shaft of the East Roman Gravels Mine down to the 109-fathom level. The average length of the levels in productive ground on this lode is from 100 to 120 yards. The Boundary or East Roman Shaft, situated 90 yards east-by-north of the New Engine Shaft, is in the Wood Mine (East Roman Gravels) sett. Its bottom is 110 fathoms below the Wood Level and is connected with Roman Gravels at that depth. The lowest level on the lode is over 346 feet below the bottom of the Milne Shaft on the Leigh Level.

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In this mine three other veins were found. A lode known as the First New Vein (? Caunter Lode) trends about W. 25° N.

through the shaft. The Caunter Lode averaged 4 feet wide of solid galena. The Wood Level was diverted for some yards south-eastward along the Ladywell Vein and then carried south-westward again through an air-shaft to the east-and-west Quarry or Pool Vein, underlying north, upon which there was an engine shaft¹ intended to work the Ladywell, New and Pool Veins, and the New Britain Vein to the south. The level was diverted westward along the Pool Vein (in the direction of Marsh Pool), which, however, was not fully explored, the mine having been badly managed. Lead was produced from 1875 to 1880 inclusive, and although blende occurs, it was not shown in the returns.

An old plan² of 1844 shows the proposed continuation of the Wood Level to the East Grit Mine. This was apparently carried out at a later date—according to the accounts of old workmen—the level leaving the Pool Vein about 200 yards west of the New Engine Shaft and trending east of south for over half a mile, passing Taylor's New Pit (150 yards south-west of the engine-shaft) and following the course of the *New Britain Vein*. Upon this vein there are two shafts,³ 200 yards apart, the northern at the intersection with a 'First Roman' Vein, the second with a 'Second Roman' Vein, each trending a few degrees north of west. The New Britain Vein was worked by the Farmers' Co. (p. 10) down to 15 fathoms. Lead carbonate was got near the surface, and later the sulphide was found below. This was apparently before the Wood Level had been driven beneath the mine.

About 500 yards north-east of the New Britain shafts there are one or two old shafts on Shelve Hill about which we have no information.

The Wood Level continues its course to the East Grit Engine Shaft⁴ on the Foxhole Vein,⁵ which trends north-westward and has been worked at the Foxhole Pit,⁶ 500 yards in that direction, as well as at the East Grit shaft. At the *Foxhole Mine* ore was worked from the surface to a depth of about 45 fathoms, the water draining to the Grit Mines. At the bottom a run of good ore, 32 fathoms in length, was found. Immediately eastward of the shaft the vein splits, the north or main vein here hading northward and bearing slightly south of east, the south branch bearing south-eastward and underlying to the south-west. A 'Quarry Vein,' underlying north, to be distinguished from the above-mentioned Pool or Quarry Vein in Ladywell Mine, strikes nearly parallel to the Foxhole Vein at about 80 yards distance to the north-east.

¹ Lat. 52° 35' 10", long. 2° 59' 34".

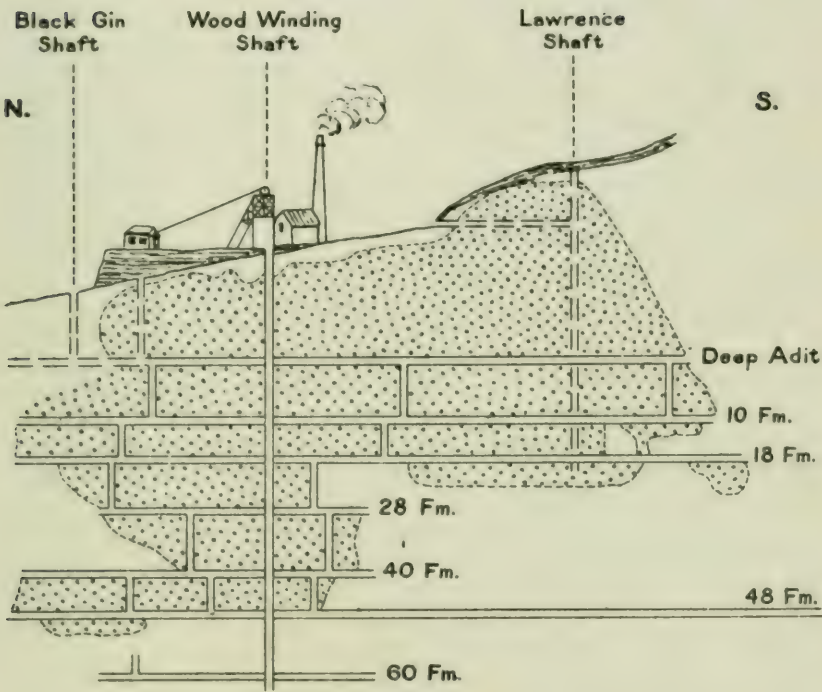
² Preserved in the office of the Shropshire Mines Ltd.

³ Shown on the six-inch map, Shropshire 47 S.E.

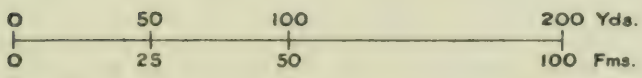
⁴ Lat. 52° 34' 39", long. 2° 59' 34".

⁵ Presumably the 'Engine Vein' referred to by Murchison, 'Silurian System,' 1839, p. 278.

⁶ Lat. 52° 34' 46", long. 2° 59' 55".



Approx. height of Leigh Level at Wood Shaft



LONGITUDINAL SECTION OF THE WOOD LODGE.

Grit Mines.—This is an important group that may be treated as a unit. In the *East or Old Grit Mine* (Fig. 7, p. 22), about three quarters of a mile south-west of Shelve, there are three important veins: the Rider, the New, and the South Vein, the Rider forming the middle link of a Z-shaped figure in which the New and South Veins form the top and bottom respectively. The Foxhole Vein is present also.

At the Rider Shaft¹ the Rider and South Veins are in contact, diverging eastward. The former, traceable to this point from the White Grit Mines farther west, trends north of east and underlies south at a high angle, approaching the vertical in depth. It continues for a distance of 300 yards almost to the Bye Pit, situated 60 yards south-west of the East or Old Grit Engine Shaft mentioned above. The South Vein trends east-south-east and underlies north at about 70° from the horizontal. On this vein the New Engine Shaft is situated 300 yards east-south-east from the Rider Shaft and 170 yards south of the Bye Pit.

The Rider Pit is 60 fathoms deep, with a day-adit (? draining westward) at 180 feet. The Bye Pit is 60 fathoms and the New Engine Shaft 100 fathoms deep, whilst the East or Old Grit Engine Shaft falls short of 60 fathoms.

The Rider Vein has been stoped from the outcrop to below the 60-fathom level. At a point where the New Vein crosses it, a short distance west of the Bye Pit, there was a large swallow at the 60-fathom level into which the ground collapsed when being worked. This ground was therefore abandoned, although rich. The swallow extended downwards for a long distance, and the Rider occurred on the east side of it. The Rider extended as a strong ore-bearing vein for only a short distance west of the Rider Shaft.

The New or Red Vein runs north-westward across the Rider in the neighbourhood of the swallow. It yielded good ore at and slightly above the 60-fathom level. It is difficult to tell, from the plans, in which direction this vein fades, though apparently it is southward.

The South Vein has been worked extensively from the 60- to below the 90-fathom level, especially at its eastern end, beneath the cross-course near the New Engine Shaft. Westward, between the levels, there appears to be a good deal of unproved ground in which ore has been found in the floors. A swallow occurs on the 90-fathom level a little east of the New Engine Shaft. By 1869 upwards of 9,000 tons of ore had been got from this vein, in bearing-ground about 50 fathoms in length, and the vein was found to be still richer at greater depths. At that date the 90-fathom drive up to the Rider Vein had opened into a strong pipe of ore, which opened in the Rider Vein each way to meet the 80-fathom level at the swallow.

Near the Bye Pit and New Engine Shaft the veins are cut off eastward by a cross-course trending about E. 8° S., and having

¹ Lat. 52° 34' 35", long. 2° 59' 50".

eastward at about 45° . This is ore-bearing near the Bye Pit, and has been referred to as the Foxhole Vein. It is more likely, however, that the cross-course is the southward continuation of the New Britain Vein farther north, since it is exactly on its line, and not the Foxhole Vein, which has quite another direction (p. 18).

In the *West Grit* or *White Grit Mine* the chief veins are the Rider and the Squilver¹ or Dingle. The Broomyfield Vein lies between this mine and the one just described.

The Rider Vein continues westward through the Blue Pit (270 yards west of the Rider Pit) to the West Grit or White Grit Mine, the West Grit main shaft² being 280 yards west of the Blue Pit and west of the main road. The Rider Vein has apparently been explored and worked at intervals between this mine and that last described. It is traversed by the adit and a 60-fathom level. The Blue Pit is 80 fathoms deep and the adit is there at 20 fathoms: at the Rider Pit it is at 30 fathoms. The Blue Pit and the West Grit Pit are connected by an 80-fathom level.

The Broomyfield Vein crosses the Rider 150 yards west of the Rider Pit. It trends south-eastward, parallel to the South Vein, towards the East Grit cross-course and fades south-westward. Promising pockets of ore have been found, reaching to the surface: but the vein has been little worked. A drift of 70 fathoms length was made on it, when the miners were stopped by hard ground.

Westward of the West Grit main shaft the Rider Vein was lost in shales³ (presumably the Hope Shales as defined above, p. 4), which apparently dip westward at about 45° .

At the West Grit main shaft, 100 fathoms deep, the Squilver (or Dingle) and the Rider Veins are in contact, and a large body of ore, forming a pipe, was raised from the Squilver at 60 fathoms depth at this point. The pipe, which was 300 feet in length, is considered to go 40 fathoms deeper. No cross-cut, however, seems to have been made from the shaft to the Squilver below the 60-fathom level, although the Rider was explored to 100 fathoms.

The Squilver or Dingle Vein (Fig. 8, p. 24) trends south-eastward for about 700 yards, its underlie being south-west. It has been explored by numerous shafts, the chief, in order, being West Grit main shaft, Gough's, Old, Garden, Stone (530 ft.), Flat Rod, Hampson's, Footway or Angle Rod, and Dingle⁴ Shaft. South of Hampson's⁵ the vein appears to bifurcate, the southern branch forming the Dingle Vein, which

¹ From Squilver, a farm house half a mile to the south-east. The name is a corruption of Disgwylla (Welsh—a place of observation), by which designation it was known up to 1836, and probably still later.

² Lat. $52^\circ 34' 31''$, long. $3^\circ 0' 15''$.

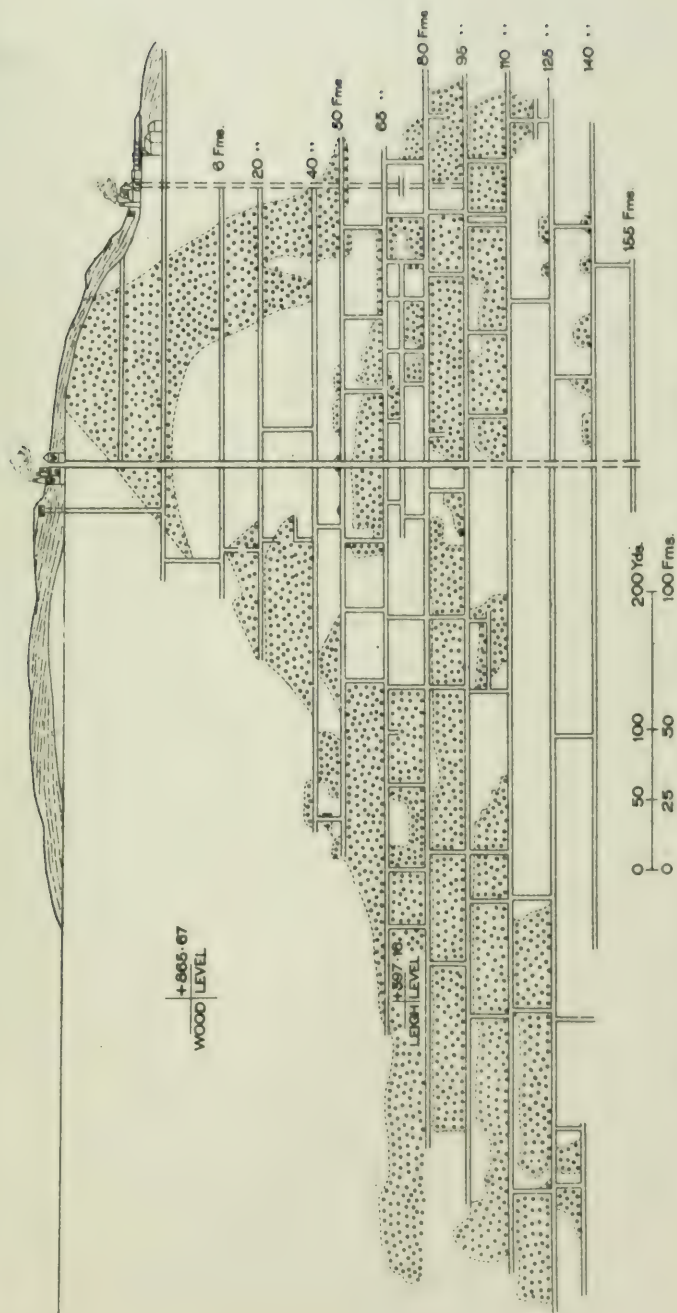
³ Morton, *op. cit.*, p. 31.

⁴ Lat. $52^\circ 34' 19''$, long. $2^\circ 59' 56''$.

⁵ Lat. $52^\circ 34' 24''$, long. $2^\circ 59' 59''$.

S.

N.



LONGITUDINAL SECTION OF THE ROMAN VEIN.

would probably repay further exploration, as indications are good. At the last two shafts mentioned there are levels at 40, 50, and 60 fathoms; north westward the chief levels are at 40 and 60 fathoms. Between the Garden and the Stone Shaft the vein was worked to outcrop, whilst between Gough's and the Garden there are few or no stopes. Besides the rich pipe of ore found near the Rider Vein, another was discovered and furnished 4,000 tons of ore. A bed of 'spar' was found at the bottom of the Flat Rod Shaft.

The Rider and Squilver Veins were being worked in the time of Murchison,¹ who wrote as follows:—"The course of the "Rider" is marked on the surface by the protrusion of a mineral mass of highly inclined, quartzy hornstone, three or four feet thick. These veins [the Rider and Squilver] traverse the sandstone and shale, the beds of which strike from N.N.E. to S.S.W. and dip 25° to the W.N.W. on one side of the hill, and to the east on the opposite side. The engine shaft is forty fathoms deep, other shafts are seventeen fathoms, but formerly the Squilfa vein was worked at seventy and eighty fathoms. The veins are very irregular in width, varying from six inches to six feet, and bade at a high angle to the S.S.W. There are two varieties of galena, the common and the steel grained: also carbonate of lead both crystallized and stalactitic. The other simple minerals are sulphate of barytes, crystallized quartz, and chalcodony, with a little lime and blende, the former sometimes coating crystals of quartz. The most beautiful mineral of these mines is the white stalactitic carbonate of lead. The ore in the grit [Grit] mine is also frequently associated with a decomposed, black, sooty substance, probably earthy oxide of manganese mixed with other materials, which sticks like paste to the ore and cannot be separated from it without much washing In all these veins many separate strings diverge from the chief body of 'stuff,' the best and richest ore being usually found in the bunches or points of intersection. The ordinary ores afford six to seven ounces of silver per ton."

Galena was being raised from the Grit Mines in 1845, when the first official returns were published, and again in 1846. In 1851 the output was 781 tons; in 1853 and 1854 the combined output was 1,501 tons. From 1856 to 1866 a continuous output was maintained, the first year showing a maximum of 983 tons. At a much later date, 1898 to 1901, a total of 297 tons was got, in addition to 13 tons of blende. Barytes, some of which is bituminous, also occurs here, and witherite also has been found.

Various trial-shafts and levels have been made on the eastern side of the Shelve Anticline. At *Shelve Pool Mine* the shaft,² situated 500 yards east-south-east of the New Engine Shaft of the East Grit Mine, was sunk 78 feet, apparently on a vein, about 1882-1886, but no serious mining was done.

¹ 'Silurian System,' 1839, p. 278.

² Lat. 52° 34' 25", long. 2° 59' 14".

South Roman Gravels Mine.—This is situated on what is known as the Shelfield Main Lode, about 200 yards south-west of Shelfield Farm, at a point where the large southward-hading fault of the East Roman Gravels Mine breaks across the eastern side of the anticline. The lode appears to be a nearly east-and-west flier off the north side of this fault, and hades northward.

The Engine Shaft¹ (956 ft. O.D.) reaches to a little below the 30-fathom level below adit, which is at 72 feet depth and opens to daylight some little distance eastward. Levels have been driven at adit-level and at 10, 20, and 30 fathoms below. Lead-ore has been stoped above adit-level to the west of the Engine Shaft, where work was aided by a secondary shaft to the adit. In the 10-fathom level a little ore had been got east of the shaft before 1879. Ten tons of ore were returned officially in 1875 and two in 1879.

Farther north a lode is said to occur between Shelfield and Nick Knolls.

EASTERN AREA: CALLOW HILL-BOG DISTRICT.

A small mine was worked for a few years on the eastern outcrop of the Mytton Beds at *Callow Hill*,² two-thirds of a mile east of Minsterley. The vein occurs on the southern side of an east-and-west intrusive dyke, but is in contact with it at its eastern end only. Several old shafts and adits mark the workings in the vein. At the mouth of the upper adit, the diabase dyke, along which the adit has been driven, is normal and unaltered; but on being followed eastward up the adit to the point where it meets the vein a change is noticeable, and at the contact the dyke has undergone profound alteration, having suffered sericitization.³

A total of three tons of galena and one of blende was returned from this mine in 1890-91.

Snailbeach Mine.—On the eastern outcrop of the Mytton Beds this is the most northerly mine of importance. The attention of geologists was directed to it by Arthur Aikin⁴ as long ago as 1797.

Plans dated 1790 are in existence of mines here; but at an earlier date (probably the 12th and 13th centuries, when lead was obtained in abundance in this region) the 'old men' must have been at work, for many of their excavations are met with in opening up for barytes.

The vein⁵ occurs nearly if not quite on the line of the Snailbeach Fault, a downthrow south, and extends right across the outcrop

¹ Lat. 52° 35' 27", long. 2° 58' 15".

² New Series One-inch Ordnance Map, 152 (Shrewsbury); six-inch, Shropshire 40 S.W. Old Series One-inch Geological Map, 61 N.W. Lat. 52° 38' 17", long. 2° 54' 30".

³ T. C. F. Hall, 'Report on the Shropshire Mining District,' *Lond.*, 1919, p. 19. (*Cf.* the Rider Vein of the Grit Mine, p. 4.)

⁴ 'Journal of a Tour through North Wales and Part of Shropshire,' 8vo., *Lond.*, 1797, pp. 203-5.

⁵ Six-inch map, Shropshire 48 N.W.



PLAN OF THE EAST GRIT MINE.

from the Stiperstones Quartzite on the east to the Hope Shales on the west; it trends almost east and west over its western half, and swings east-north-eastward at its eastern end.

It has been worked by five shafts (Fig. 9, p. 26), from west to east as follows, datum-level being 1,811 feet O.D. (*i.e.*, 1,000 feet above the top of the Ladder Shaft): Ladder Shaft, to the 252-yard level; Engine Shaft,¹ 120 yards south of the above, vertical to the 342-yard level, and with an incline from the 282-yard to the 462-yard level; Black Tom Shaft, to the 40-yard level, chiefly used for raising barytes; an underground haulage-shaft, in the east centre of the mine, inclined southward down the hade of the vein from the 342- to the 552-yard level; and finally the Chapel Shaft, to the 342-yard level. This last, which is situated 720 yards east of the Engine Shaft, has been used for ventilation alone.

The 112-yard or adit-level is actually 445 yards below datum. The water from it drains westward and drives a water-wheel furnishing part of the power at the Cliff Dale Barytes Mill in the Hope Valley.

The vein has been worked to a depth of a little over 552 yards, from numerous levels, 30 yards or more apart, those below 462 yards prevailing in the east centre of the mine. Westward the levels of intermediate depth, such as those from 252 to 342 yards, run beneath the outcrop of the Hope Shales; eastward the highest levels approach most closely to the outcrop of the Stiperstones Quartzite. In the western half of the mine ore occurred more patchily than in the eastern half. West of the Engine Shaft the ore was got chiefly between the 192- and 432-yard levels. Between the Engine Shaft and the inclined haulage-shaft it was got from near the surface to the 552-yard level, and east of the latter shaft from the 40-yard level to the bottom of the mine, the greatest amount being obtained from below the 192-yard level.

The inclination of the vein, which in general is approximately 50° from the horizontal, increasing to 60° near the bottom, suffers changes here and there, steepening and passing through the vertical for a space before recovering its normal direction. This occurs between the 40- and 192-yard levels in the eastern part of the mine, and between the 112- and 192-yard at the western end. Near Black Tom Shaft the hade is nearly vertical for 40 yards.

The Main Vein described above is accompanied by a parallel South Vein, at a chain's distance, which has yielded ore here and there, *e.g.*, west of the Engine Shaft between levels of about 230 and 312 yards, and in the east centre of the mine between the 186- and 252-yard levels, as well as on the 402-yard level.

Several cross-cuts have been made to find other lodes. One at the 80-yard level runs northward for 300 yards from about 20 yards west of Black Tom Shaft. A second, at the 282-yard

¹ Lat. 52° 36' 44", long. 2° 55' 26".

level, under Lordshill Farm, is carried 230 yards in the same general direction, whilst a third runs southward for 450 yards from the 112-yard level at the Chapel Shaft.

A few levels at 40 yards, *i.e.*, nearer the outcrop, have been run along the lode or across the measures in search of barytes: one of these is the Perkins Level,¹ where the Main Vein is accompanied by a 'back' vein.

The main lead-vein had regular walls and was occasionally about 22 feet in width, but more usually from 8 to 10 feet, and is said to still hold good. In the richest parts the galena² occurred as a good rib in long 'shoots,' 40 to 50 yards in length; but where the vein was wide it occurred as one or two ribs in the gangue. At the bottom of the haulage-shaft at the deepest part of the mine the ore ran to three tons to the fathom, and at the bottom of the Chapel Shaft it yielded two tons to the fathom. Blende occurred in greatest proportion in depth; below the 400-yard level the ratio was about 10 per cent. of blende to 90 of galena. Cerussite also has been obtained.

The vein-stuff was chiefly calcite, with quartz in cavities on the hanging-wall. One vugh measured 48 feet by 21 feet by 1 foot. Quartz occurred as good crystals on large rhombohedra of calcite, or by itself as acicular crystals. The gangue contains barytes also, chiefly in the higher part of the mine, and barium carbonate (witherite) occurred as balls at the 252-yard level.³ No copper occurs here, but iron pyrites is found. Fluorspar also was got, as well as red oxide of lead (minium).⁴

Before the pumps ceased work in 1909, and water allowed to accumulate up to adit-level, 21 men in 5 weeks got 65 tons 12 cwts. of lead-ore between the 492- and 500-yard levels without resorting to plundering. At that date 5,000 gallons of water per hour were raised by the pumps. This was all surface-water, only a few small feeders being tapped during the mining.

Formerly the ore used to be dressed here and smelted in the neighbourhood, but the plant has been dismantled. The tailings and floors yielded 56 tons of galena and 39 tons of blende in 1912-13. The output since 1845 is shown in the diagram (Fig. 13).

The mine is now worked, chiefly above adit, for barytes, which occurred down to below the 152-yard level west of the Engine Shaft, and has been got uninterruptedly for 20 years. In 1919 work was in progress down to the 40-yard level, from Black Tom Shaft and Perkins Level, on a vein 8 feet in width, and a little galena is got here in ribs alongside the barytes, 50 tons having been obtained in the last two years.

¹ 'Special Reports on the Mineral Resources of Great Britain,' vol. ii. Barytes and Witherite (*Mem. Geol. Surv.*), ed. 2, 1916, pp. 59, 60.

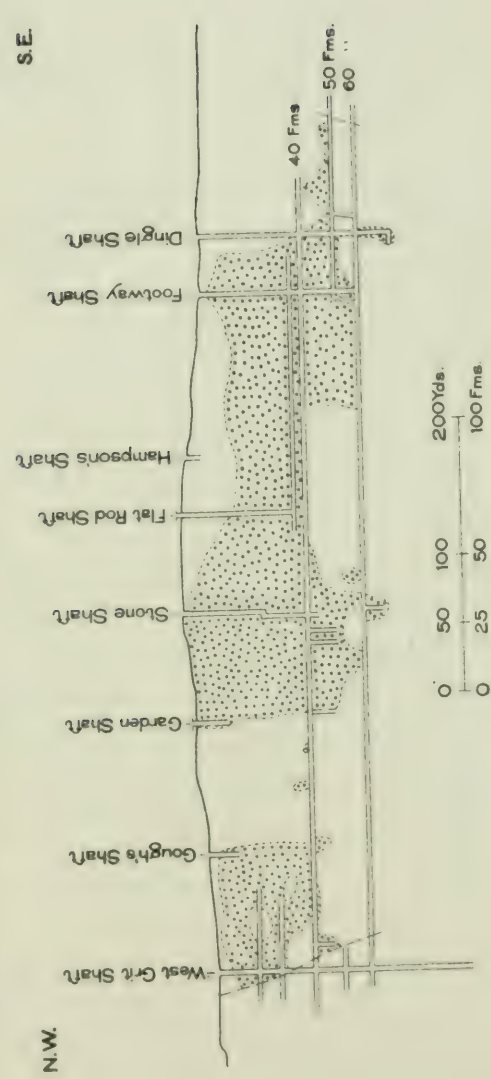
² In the old days, steel-ore with silver was found. See Aikin, *op. cit.*, p. 20.

³ 'Special Reports,' *op. cit.*, p. 59.

⁴ Aikin, *op. cit.*, p. 204.

Fig. 8.

Special Mineral Reports, Vol. XXIII.



LONGITUDINAL SECTION OF THE DINGLE VEIN.

As regards the future of the mine, it is stated that there is still much ore in sight, in the deep, especially at the eastern end of the mine, but it must be recalled that the Stiperstones Quartzite is near at hand. The 252-yard level from the Chapel Shaft, driven in 1866 eastwards along the vein, traversed 160 fathoms of shale and apparently entered the Stiperstones Quartzite, which was found to dip rather steeply westward, and would therefore be met with sooner in the deeper levels. This end of the mine was worked with difficulty from the underground haulage-plane, the ore being carried westward along the 342-yard level to the Engine Shaft. If the Chapel Shaft were deepened and fitted for drawing, this end of the mine would be more accessible. Ores raised here are carried three miles on a narrow-gauge railway to the G.W. and L. & N.W. Joint Railway near Minsterley.

North of the Snailbeach Mine a few spar-veins have been located. The Sandhole Vein, ranging nearly east and west, traverses the highest part of Snailbeach Coppice at about 570 yards north of the Chapel Shaft. Some 250 yards farther north is the Quarry Vein, trending west-south-west. Foxhole Level, 100 yards still farther north, was an attempt to cut this vein; whilst in Maddox's Coppice, 770 yards east of the old smelting-works, a level has been driven southward to a vein apparently on the line of a fault trending parallel to the Quarry Vein.

South of the Snailbeach Mine some veins known as the South Vein, the Sandhole Vein, the Stony Dingle Vein and Robert Everall's Vein occur in order, trending a few degrees north of east and hading southward. Taylor's Vein crosses them as a counter-lode trending north-west and hading south-westward. These veins were exploited by the abandoned *New Central Snailbeach Mine*. The old engine shaft¹ is situated 170 yards west-south-west of the Cross Guns Inn at Crowsnest, and a deep adit-level from the South Vein runs north-westward past the shaft to the small stream that flows through Josey Wood, a total distance of 640 yards. There is a shaft on this adit-level 160 yards north-west of the old engine shaft. A total of 126 tons of lead-ore was got from the New Central mine in 1871-2.

Myttonsbeach Mine.—This is 5 furlongs farther south, and apparently worked the Mytton Dingle Vein, which trends about E. 9° S. and hades southward. The vein, like those in the New Central mine, does not appear to displace the strata.

Perkins Beach Mine.—This mine² lies on the southern side of Green Hill, about half a mile south of the last. The chief lode here is the Big Spar Lode, which traverses almost the full width of the outcrop of the Mytton Beds in a direction about E. 15° N. In the west it has been worked at the *Burgam Mine*, but it seems to have been mineralized at intervals only. In Perkins Beach

¹ Lat. 52° 36' 27", long. 2° 56' 1".

² Six-inch map, Shropshire 48 S.W.

it underlies south, and was worked from Maddox's Shaft,¹ 150 yards west-south-west of the mine-offices, and also, apparently, from three old shafts within 150 yards east of the offices. Farther east, again, it has been worked for lead and barytes, and about 200 yards north of this there is a nearly-parallel Criss Vein, underlying south, and an oblique Chimney Vein. That part of the lode lying west of the offices was reached by a cross-cut or deep adit (at 943 feet, rising to 1063·89 feet O.D.) driven from the valley to the north: this was being cleared out in Nov. 1919. The central section, near the offices, was drained by a deep adit that runs to the Criss Vein also.

The mine was worked as a lead-mine to a depth of 90 feet below adit-level and a fairly constant output was maintained from 1870 to 1891, the maximum yearly output being 200 tons, in 1871. The combined output for 1893-4 was 321 tons. The chief obstacle to working was heavy water at certain seasons.

The Big Spar Lode, shown by Lapworth² as a fault, with a maximum width of 8 yards, but with never more than 6 feet of spar, is now worked for bituminous barytes, and calcite is not common. It is proposed to drive an adit, 60 feet below the present bottom adit, from the valley on the north. There are good indications of lead in depth, and the Criss Vein also carries lead.

Burgam Mine.—This mine, situated 800 yards west of Maddox's Shaft (Perkins Beach), worked the Big Spar Lode and also a lead-vein on a north-and-south line. It yielded 19 tons of galena in 1867, and 20 tons in 1893, when 4 tons of blende also were obtained.

This mine, and those south of it, are drained in their higher parts by the Boat Level, which issues at about 900 feet O.D. at a point 550 yards south-south-west of Stiperstones School. It runs south-south-west by way of the old lead-shaft of the Burgam Mine to the Lewis Shaft³ of the Tankerville Mine, where an offset westward to the Old Engine Shaft of that mine served for draining. South of the Lewis Shaft it traverses the old Potter's Pit Mine and proceeds to the Pennerley Mine, where, after making an elbow about the Gin Shaft, it turns south-south-eastward in the Hope Shales to the Bog Mine. Thence it continues southward, crossing the narrow outcrop of the Mytton Beds to the Nipstone Vein on the Stiperstones Quartzite. The total length of this adit, without branches, is approximately 2½ miles.

Tankerville Mine—This mine, known also as the Oven-pipe, lies north of Pennerley and 3½ miles south-south-west of Minsterley. The Old Engine Shaft is 350 yards south-west of the Burgam Mine shaft and 130 yards west of Lewis Shaft.

The ore-bodies in this mine (Fig. 10, p. 28) are of a peculiar type, to which the name of 'oven-pipe' has been aptly applied.

¹ Lat. 52° 35' 29", long. 2° 56' 16". Surface-level 1032·54 ft. above O.D.

² On a MS. six-inch map deposited at the Geological Survey Office.

³ Lat. 52° 35' 21", long. 2° 57' 0".

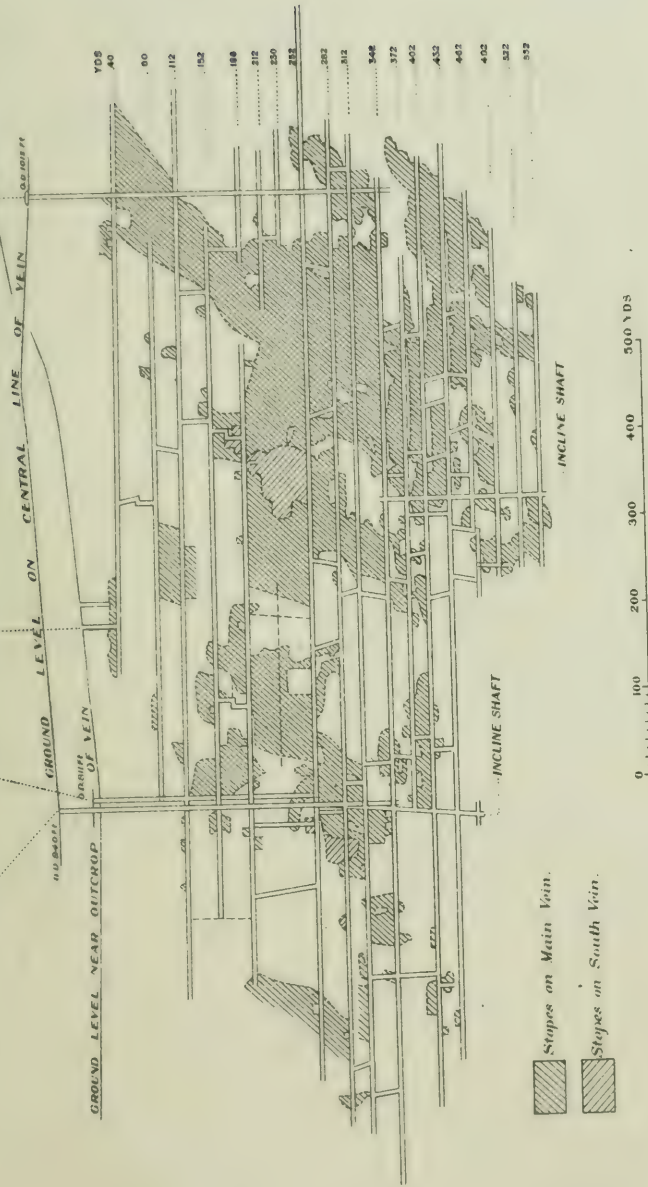
ف

ENGINE
SHAFT

LADDER
SHAFT

BLACK TOM
SHAFT

CHAPEL SHAFT
(AIR SHAFT ONLY)



LONGITUDINAL SECTION OF THE SNAIL BEACH LODGE.

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They consist of finger-like 'shoots' of ore, following the steep dip (north-west at 50° to 60°) of the Mytton Beds beneath their cover of Hope Shales, and possessing width and thickness of about equal dimensions. Thus the main levels shown on the plan of the workings run about north-east and south-west at a pronounced angle to the direction of pitch of the shoots; almost parallel, in fact, to the strike of the rocks; whereas the shoot follows a transverse fracture in the direction of dip. The bodies are thus a combination of vein and flat, and the flattening out may be due to incipient strike-faulting that develops farther south.

The transverse fracture (or fractures) in which these bodies occur has been traced at the surface by Mr. T. C. F. Hall, and found to trend west-north-west and east-south-east and to fade southward, but the strata are not greatly displaced.

The beds overlying the pipes consist of that part of the Lower Arenig which we have included on lithological grounds with the Hope Shales (p. 4).

The Old Lode consists of two finger-like shoots or pipes, probably separated by shale, which crop out slightly west of the Lewis Shaft on the Boat Level, and east of the Old Engine Shaft (Fig. 10). They shoot westward, following both the dip of the beds and the hade of the fault, and have been worked from the Old Engine Shaft (1119·69 feet O.D.) to a depth of 90 fathoms below the Boat Level, or 679·4 feet from a surface-level of 1050 feet. The Old Lode has also been touched at the 192-fathom level. The Old Engine Shaft goes to the 74-fathom level, and is an incline below the Boat Level, which, in this mine, is 139·4 feet from the 1050 surface-level.

The Main Lode or pipe lies a little south of the Old Lode and does not come to outcrop. It has been worked from about 300 feet to 1,542 feet (232 fathoms below the Boat Level) from the surface. The bottom level of the mine is the 244-fathom, 1,614 feet from the 1,050 feet surface-level, or 559 feet below O.D.

The lode was worked from Watson's Engine Shaft (1131·38 ft. O.D.), situated 60 yards south-west of the Old Engine Shaft. Watson's Shaft is vertical to the 52-fathom level, below which it follows the inclination of the lode to the 244-fathom level. The top of the pipe is narrow, but the bottom opens out to a maximum breadth of about 140 yards. A South Lode, parallel to the above, has been worked here and there.

A North Lode, or branch off the Main Lode or pipe, has been worked between 182 and 232 fathoms. The 220-fathom level in this ore-body is about 35 yards in length.

The New Shaft, connected underground with Watson's, is situated about 100 yards south-east of the latter.

The mine has been abandoned for many years. The extensive dumps contain a large quantity of well-crystallized calcite, some purplish or amethystine, coated with crystals of quartz and

evidently from 'vughs,' with galena, blende, and copper pyrites. There is also a considerable amount of bituminous barytes. The calcite is used for rough-casting of walls.

The output of lead-ore was continuous from 1865 to 1884, the 1866-1868 outputs including those of Burgam, Potter's Pit, Batholes and Roundhill, all then in work. During this period 17,919 tons of lead-ore were got, the maximum annual output being 1970 tons, in 1871. A little zinc-ore was obtained in 1865-6, and again in 1881-1884, amounting to little over 200 tons in all. From 1890-93 a few tons of lead and zinc ores were got, probably from the dumps.

Potter's Pit.—This lies a short distance south of the Tankerville Mine, the old shaft being situated 200 yards south-by-east of the Tankerville New Shaft, and close to the Pennerley Methodist Chapel. It is connected by a short offset with the Boat Level. Its bottom is 630 feet below this level, all the workings being on Ben Arthur's Vein. The ground was easy and rich, and many hundreds of fathoms of lead and zinc ores are reported to be left,¹ little having been taken out below adit-level. East of Potter's Pit is the Goodest Tuesday Vein, worked to a depth of 300 feet, in which lead-ore estimated at $2\frac{1}{2}$ tons per fathom is still left. Another lode is named the Pump Sump.

In 1857 some 5 tons of lead were raised: in 1866-68 the output was included with that of Tankerville, whilst in 1867 the mine yielded 95 tons.

Pennerley Mine.—This mine, which was described by G. H. Morton,² is situated four miles south-south-west of Minsterley. The Gin Shaft³ is 450 yards south-west of Potter's Pit.

The outcrop of the Mytton Beds is here bounded on the west by a north-and-south fault, with westward downthrow, which brings in the Stapeley Ashes and Shales, and on the south by a fault that ranges east-south-east, with southward downthrow, which brings in the Hope Shales.

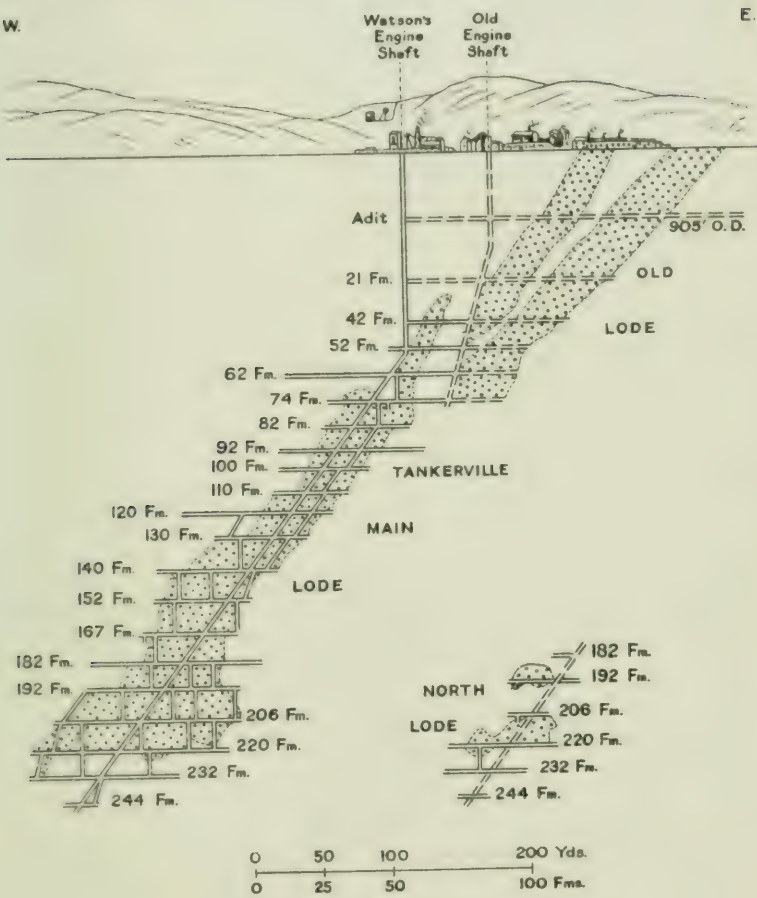
There are four important veins in this old mine, all crossed by the Boat Level. The Rider, lying north of the Gin Shaft, trends approximately east-north-east, and fades to the south. Three others, occurring parallel and close together, lie south of the Gin Shaft. They all trend north-north-eastward and fade north-westward, their names from north to south being the Big Ore, the Warm Water, and the Red Vein. The Warm Water Vein afforded a spring of water of higher temperature than that from the neighbouring veins.

Although the Rider crosses the other veins at an angle of 35° , it does not throw them off their course, nor does it appear to be

¹ From MSS. in possession of Lieut.-Col. J. V. Ramsden, D.S.O., Shropshire Mines Ltd.

² 'The Geology and Mineral Veins of the Country around Shelve, Shropshire,' *Proc. Liverpool Geol. Soc.*, Session 1868-9; separately printed, 1869, pp. 32, 33, and pl. 4.

³ Lat. $52^\circ 35' 0''$, long. $2^\circ 57' 16''$.



LONGITUDINAL SECTION OF THE
TANKERVILLE LODS.

influenced by them. To the south of these veins, which are in the Mytton Beds, the Hope Shales are thrown in by the above-mentioned fault ranging east-south-eastward.

The Rider is said to be underlain by a felspathic or greenstone intrusion.

The depth of the mine is 1,080 feet, the bottom being about 20 feet above O.D.; but very little driving has been done below the Boat Level. Murchison¹ states that in his day the Pennerley mines had been long abandoned but were about to be reopened.

Pennerley Mines were producing ore in 1845, when statistics were first published, and continued to do so till 1848. They yielded lead-ore again at intervals from 1854 to 1870 under the Stiperstones Co., the Big Ore Vein yielding the most in 1860. Later they were again worked successfully from 1871 to 1878, yielding 4,883 tons of lead-ore and 118 of zinc-ore. From 1881 to 1884 the output totalled 1,674 tons of lead-ore and 50 of zinc-ore. Still later, from 1890 until 1895, a few tons of both ores, chiefly blende, were got.

South of the Pennerley Mine the junction between the Mytton Beds and the Hope Shales is a fault, which forms a sweeping curve from north to south, with its convexity to the east.

From the Gin Shaft the Boat Level trends south-south-eastward to the Bog Mine. It has one or two shafts upon it, from which a little lead was got. One of these, on the west side of the road from Pennerley to the Bog Mine, is Hoskin's, situated 450 yards north-north-west of the Bog engine shaft.

Bog Mine.—At this mine there are three shafts arranged in a west-to-east line: the Engine Shaft, Bunting's Shaft, and an old shaft, all more or less on the strike of the main lode (Fig. 11, p. 30). The Boat Level throws off a branch from the Engine Shaft eastward to these other two shafts.

At this mine two important veins intersect at an angle. The larger, or Bog Vein, trends east and west and underlies southward. The smaller, or Whitstone Vein, trends about 25° to 30° north of west and underlies south-south-westward. The Bog Vein slightly displaces the Whitstone, throwing it down southward, the line of junction between the two veins being slightly irregular and trending west of south. The fractures in which these lodes occur do not appear greatly to shift the surface-outcrops of the Mytton Beds at this point. The Whitstone Vein, as shown on the Geological Survey Map, 60 S.E., is accompanied by a greenstone dyke.

The Engine Shaft,² an incline from the Boat Level along the hade of the Bog Vein, passes through the junction of the veins at 100 fathoms below the Boat Level. Bunting's Shaft (1,240·3 ft. O.D.), 125 yards east of the Engine Shaft, is on slightly higher ground than the Engine Shaft: it is situated on the branch of

¹ 'Silurian System,' 1839, p. 280.

² Lat. 52° 34' 26", long. 2° 56' 59".

the Boat Level, which lies at 347 feet below the surface, and the shaft bottom is 115 fathoms below the Boat Level.

The higher levels are most extensive in the Bog Vein, and lie on the eastern side of the mine: but in depth, where the veins shoot westward beneath the Hope Shales (or that part of the Mytton Beds which we include with them, p. 4), the levels in the Whitstone Vein are almost as important as those in the Bog. The veins have been stoped downwards from depths of between 300 feet and 1,062 feet below the surface, the latter depth representing the 120-fathom level below the adit; but there are levels down to the 148-fathom line.

The metalliferous portions of these veins vary from 6 inches to 2 feet in width. Eastwards the veins failed on reaching the Stiperstones Quartzite. One suffered deflection at the boundary, which it followed for a short distance.

The Somme Tunnel is an exploratory cross-cut run southwards, for about 130 yards, from a point between the 22- and the 32-fathom levels south of Bunting's Shaft.

No ore is being won here (in 1919), but preparations are afoot to pump the mine dry (which has been done twice before in past years), when it is hoped that it will yield both lead and zinc ores in payable quantity, since it is reported that several runs of ore are still untouched. There is a compressed-air plant for drilling, etc., and a dressing-plant installed; but the latter is used at present for treating the ore got from the veins farther south. The ores, with barytes, are despatched by aerial ropeway, operated by an engine at the mine, to a siding a few hundred yards north of Minsterley Station, a distance of $5\frac{1}{2}$ miles.

Lead-ore (220 tons) was raised at the Bog Mine in 1845, and an output was maintained until 1850. A little was got in 1852, 1857-8, 1861 and 1864. From 1866 to 1876 was another active period, the outputs for the first five years of this sequence being combined in the Mineral Statistics with that from Pennerley. In 1875 the output was 300 tons. More ore was got between 1880 and 1884, with a maximum of 600 tons for 1883. In the period 1871-1884 the amount of zinc-ore raised was greater than that of lead, 665 tons being produced in 1882. From 1890 up to 1902 lead and zinc ores were raised, blende preponderating over galena. From 1905 to 1909 the small amount of ores got was apparently from pickings or explorations.

Production at the Bog Mines commenced again in 1912 with 103 tons of galena and 338 of blende, and has been fairly continued since; these ores, however, are not from the old mine, but from the veins lying farther south, and now to be described.

From north to south these veins are No. 6, No. 8, No. 9, and the Nipstone, all occurring in a narrow outcrop of the Mytton Beds, apparently faulted on both sides, with the Stiperstones Quartzite on the east and the Hope Shales (including the top of the Lower Arenig, p. 4) on the west. They are all traversed by the Boat Level, which ends at the Nipstone.



LONGITUDINAL SECTION OF THE LODS
AT THE BOG MINE.

No. 6 vein is within 50 yards southward of Ramsden's Shaft,¹ which is situated 420 yards south of the Bog Engine Shaft, and is a new shaft, sunk 390 feet to the Boat Level in 1915. It is intended to sink it 600 feet deeper. The vein trends east and west and underlies north, and is expected to touch or intersect the Bog Mine veins in depth. It has been worked since 1912 to 60 fathoms below the Boat Level, and averages 11 per cent. of lead and zinc ores, with a little calc spar and a high proportion of barytes. It is estimated that 3,000% worth of galena and blende were in sight in 1912.

The vein is from 1 to 3 feet in width, with bunches of blende 10 inches wide, and of galena 3 inches wide, in places. Barytes is most common above the Boat Level. The water in this vein is in communication with that in the Bog Mine.

A barytes vein, which lies about 150 yards farther to the south-east, was worked from Tew's Shafts Nos. 1 and 2. It trends north-west and underlies north-east.

No. 8 vein trends north-west and south-east and underlies south-west. It lies in 6 in. Shropshire 55 N.W., 420 yards south of Ramsden's Shaft.

No. 9 Vein, about 500 yards south of Ramsden's Shaft, trends east-south-eastward and swings eastward, with a south-south-westward underlie. Lapworth shows it on his map as a fault. It has been stoped to the Boat Level, and is now being worked 22 fathoms below, chiefly for barytes. The vein is about 5 feet thick, and the amount of galena and blende is increasing in depth, although at present these ores are not obtained in commercial quantities. The barytes is taken by the Boat Level to Ramsden's Shaft.

The Nipstone Vein, nearly east and west, about 150 yards farther south, is apparently on a fault that fades northward and crosses the outcrop of the Stiperstones Quartzite. It has been worked to 88 feet below the Boat Level, *i.e.*, to 590 feet below the surface. Development is proceeding here. Barytes alone occurs down to the Boat Level; but below, and within 200 feet of the shales on the west, the vein contains lead and cerussite in vughy ground with a little calc-spar but very little barytes. The vein is about 1 foot wide, with open sides, and the ore is scattered in it. The vein is accompanied by small stringers of ore running into the bedding-planes and along subsidiary fractures.

Analyses of the blende obtained from the above-described group of veins are given on p. 9.

Rock House Mine.—Half a mile farther to the south-west, and $2\frac{1}{4}$ miles north-west of Norbury, the Rock House Mine² worked ore in the Mytton Beds, in two veins, trending north-east and north-west respectively. The north-west vein appears to be 2 to 3 feet in width. There is apparently a good deal of

¹ Lat. $52^{\circ} 34' 13''$, long. $2^{\circ} 57' 2''$.

² Shropshire 55 N.W. Lat. $52^{\circ} 33' 35''$, long. $2^{\circ} 57' 45''$.

galena, not only in the vein-stuff, but also in the country-rock, in which strings and crystals of that mineral are scattered abundantly near the vein. This fact added to the absence of any true leaders through the 'pinches,' makes the vein difficult to follow.¹ Barytes also occurs here, and a little has been got recently.

On the side of the Rock (Stiperstones Quartzite) a shaft, 120 feet deep, has been sunk on the north-east vein, which has been worked for lead and barytes.

A few pickings of galena were got from Rhadley and Rock Mines in 1907-8.

Rhadley Mine lies on the summit and north side of Black Rhadley Hill, 2 miles north-west of Norbury, and was a barytes mine, only a few specks of galena having been obtained.²

CENTRAL AREA : BUXTON HILL-CEFN-GWYNLLE DISTRICT.

The Mytton Beds, as explained above (p. 3), pass beneath the syncline of Buxton Hill (Fig. 1, p. 4), where Hope Shales form the surface on the axis of the fold. Farther north and south, outliers of Stapeley Ashes and Shales overlie the Hope Shales and support small outliers of the unconformable Silurian rocks. The occurrences of lead-ore in the Stapeley rocks are sporadic and differ in character from those in the Mytton Beds.

The *Roundhill* or *North Tankerville Mine* is situated on the line of the Tankerville Fault, a quarter of a mile west-north-west of the Tankerville Mine (p. 26). At this point the fault throws the Hope Shales on the north against the Stapeley Ashes on the south, and hades southward rather steeply. Ore was evidently obtained from the Stapeley Ashes. To east and west of the mined area are outcrops of intrusive rocks, masses of which occur in the dumps, whilst the ashes themselves are cut off on the east by a north-and-south fault, which throws against them the Hope Shales and the underlying Mytton Beds, mined at Tankerville and Pennerley.

We know of no plans of this mine. The main shaft³ appears to be situated close to the mine buildings, whilst a second lies just south of the outcrop of the fault, 100 yards to the north. An old level has been driven to the mine northward from the hollow on the south-west of the mine buildings; a second appears to traverse the fault-plane eastward from a point 270 yards north-west of the mine, whilst a third has been driven southward in the Hope Shales, north of the fault.

¹ 'Special Reports on the Mineral Resources of Great Britain,' vol. ii, Barytes and Witherite (*Mem. Geol. Surv.*), ed. 2, 1916, pp. 57-8.

² 'Special Reports,' *op. cit.*, p. 57. The mine is situated in the six-inch map, Shropshire 54 N.E., and is not the same as the Rhadley Mine described on p. 33.

³ Shropshire 48 S.W. Lat 52° 35' 24", long. 2° 57' 30".

The vein is said to be 6 to 7 feet in width. The dumps contain galena, blende, calcite and barytes, with a little quartz and minute crystals of pyrites. They have been recently picked over for barytes. The mine is said to have been worked to a depth of 130 yards, but is now waterlogged.¹

In 1846 an output of 11 tons of lead-ore was recorded. From 1854 to 1863 a continuous output was maintained, amounting to 2979 tons, 491 tons being raised in 1858. A little ore was got here in 1867 and 1868 and again in 1873, whilst pickings have been returned for 1885-7, 1894-5, and 1906-7. No blende appears to have been got for sale.

The prospects of obtaining ore from the Mytton Beds in virgin ground to the north of this spot are discussed above (p. 12).

About a mile and a quarter to the south-south-west, and nearly a mile west of the Bog Mine, the old *Ritton Castle* or *West Stiperstones Mine* is situated,² also on the Stapeley Ashes, on the eastern side of the syncline. An old shaft lies 120 yards west-by-south of Ritton Castle farm-house, and about 70 yards south-east of this is a trial-shaft. Other old shafts are to be seen 160 yards north-north-west of the house. At 120 yards to the north-east of the same building there is an old level opening on a small valley.

We know of no plans of this old mine. On the Old Series One-inch Geological Map, 60 S.E., two veins are shown, one trending east and west, the other branching out south-eastward from the south side of the former. Murchison³ describes operations here as follows:—"A vein of lead ore crosses the alternating beds of felspar, breccia, and shale. . . . a gallery was formerly driven in, but is now abandoned. This vein is two to three feet wide, and is directly at right angles to the strike of the strata, which are at this point a little deflected from their regular bearing of N.N.E. to E.N.E. They dip 45° N.N.W." The dip of the beds measured at a point 160 yards north-east of the above-mentioned level is west-north-west at 50°.

The mine has been abandoned for many years. One ton of lead-ore is returned in the official statistics for 1874.

About two miles south-south-west of Ritton Castle is the old *Rhadley Mine*, on Cefn-gwynlle.⁴ This lies chiefly on the Stapeley Ashes; but on its eastern boundary a faulted strip of the Hope Shales occurs as well as Mytton Beds, and one or two of the shafts and trials in the Hope Shales may have been made to find and work ore in the Mytton Beds.

¹ 'Special Reports,' *op. cit.*, p. 58.

² Six-inch map, Shropshire 47 S.E.

³ 'Silurian System,' 1839, p. 282.

⁴ Corruptly spelt Cefn Gwntilly on the New Series One-inch Map, Sheet 165 (Montgomery). The shafts and levels are marked on the six-inch map, Shropshire 54 N.E. This is not the same as the Rhadley Mine described on p. 32.

Three or four shafts have been sunk upon the eastern flank of Cefn-gwynlle, one 400 yards south-east, others 750 yards east-south-east of the farm of that name, and two levels have been driven south-westward towards them from the West Onny river. These were all apparently designed to work a vein trending east-north-eastward across the hill and shown on the Old Series Geological Map 60 S.E., its hade being, perhaps, northward.

A second group of two trial-shafts and a level may be seen about 5 furlongs farther to the south-west, and 200 to 500 yards east of Pwll-lle (Pultheley). These were apparently intended to work a vein with a south-west and north-east trend, also shown on the geological map.

Murchison¹ wrote of Cefn-gwynlle as follows: "This hill is full of small and poor mineral veins which traverse the strata, and numerous trials have been made in various parts. One of these trials was in progress from the western flank of the hill when I first visited the district (1832)." He recorded further that a gallery had been driven across the inclined strata and a vein of lead-ore met with in "indurated schist" with many veins of quartz containing iron pyrites. The vein of lead-ore occurred about 242 yards from the entrance and was very thin, and when followed out to the north-east, disappeared in a mixed shaly rock. The vein-stuff contained barium sulphate, calcareous spar, and a little lead-ore. The trial was a failure.

The chief mineral raised in these mines appears to have been barytes.

OUTLYING AREAS.

Beyond the main area of the Shelve Mines, there are several other places where lead-ore has been either worked or found in minor quantities. Some of these mines are situated on the Stapeley Ashes of the main outcrop, but others occur at higher horizons, in beds of Llandeilo or of Bala age. They are mentioned here to show their relative unimportance as a source of lead when compared with those located in the Mytton Beds.

Rorrington or West Snailbeach Mine.—This is situated² in Rorrington Hill Covert, 5 furlongs south-south-east of Rorrington and half a mile north-east of Middleton, or nearly two miles west of the Gravels Mine.

The ore-bearing lodes are in the Weston or lower group of the Middleton Series of Llandeilo age, the beds consisting of a Lower and Upper Weston Grit, separated by a considerable stratum of Weston Shales. "There are said to be here three

¹ *Op. cit.*, p. 281.

² New Series One-inch Map, 151 (Welshpool): six-inch Shropshire 47 S.E. Old Series Geological Map 60 S.E. Engine Shaft: lat. 52° 35' 26", long. 3° 1' 35".

“ lodes running east and west [and throwing down south], which
 “ carry lead on top of the hill and barytes in depth, thus forming
 “ an exception to the general rule of the district, that veins with
 “ an east and west trend carry barytes on top and lead and blende
 “ in depth. The main vein, underlying south, is 7 feet thick and
 “ carries barytes mixed with calcite. . . . Near the confluence of
 “ the [Holywell] brook, which flows from Rorrington Hill, with
 “ that which runs north by the old road, there is an old adit [deep
 “ adit mouth], and further south alongside the stream are old
 “ shafts and levels, with a fairly big dump containing a good deal
 “ of barytes and calcite. Much of the barytes looks good white
 “ spar, but is stained green inside. Some of it contains crystals
 “ and nests of galena.”¹ Fluorspar also is present.

Between 1850 and 1855 the output of lead-ore was 276 tons. Two tons were got in 1858, and 10 in 1864. The mine is said to have been abandoned as a lead-mine in 1883. In 1890, however, pickings amounting to 5 tons were returned in the official statistics. It is now to be reopened to work barytes, calc-spar and lead. Two stopes have already been opened up. Hitherto the mine has not been worked for barytes.

Weston or Cliffdale Mine.—This is a barytes mine, and is situated² just within Montgomeryshire, and midway between the Marsh and Priest Weston, from which latter it is distant about three quarters of a mile east by north. It lies on the main outcrop of the Stapeley Ashes, with shales and contemporaneous andesite. The vein runs east and west, and is associated with an intrusive dyke shown on the Old Series Geological Map 60 S.E. It is, in fact, a ‘ rider ’ (p. 4). It “ is believed to be a continuation
 “ of the White Grit [Rider] lode which was worked to the east in
 “ the valley, but in this direction in the mine levels, the lode dies
 “ out so far as practical mining is concerned, and is represented by
 “ a hard breccia with thin strings of barytes and calcite. This
 “ breccia comes on after the lode has passed through some soft
 “ black shales . . . which, near the lode, are splashed with small
 “ flakes of galena. In a crosscut on the east, these soft shales are
 “ traversed by a thin sill of greenstone, about 15 inches thick.
 “ The vein dips south at about 60° to 70° from the horizontal on
 “ an average, but flattens and ‘ rears ’ considerably. It has been
 “ noted that where the lode is steeper there is less calcite than in
 “ the flatter portions. The vein averages 3 feet in thickness, but
 “ in places it ‘ twitches ’ down to a few inches, and in others
 “ swells up to 8 feet. In the ‘ twitches ’ lead-ore is occasionally
 “ met with in bunches. . . . The lode was apparently tried by the
 “ ‘ old men ’ for lead, but soon abandoned.”³ Barytes is the chief mineral, and the vein has been proved to a depth of 65 fathoms.

¹ ‘ Special Reports on the Mineral Resources of Great Britain,’ vol. II. Barytes and Witherite (*Mem. Geol. Surv.*), ed. 2, 1916, pp. 58, 59.

² New Series One-inch Ordnance Map 165 (Montgomery); six-inch Mont. 31 S.E. Lat. 52° 34′ 20″, long. 3° 1′ 45″.

³ ‘ Special Reports,’ *op. cit.*, pp. 65, 66.

Calcot Mine.—This mine, a little farther south, in Montgomeryshire, is situated¹ on the western side of Corndon Hill, half a mile east of Priest Weston. There is a shaft 180 yards south of Calcot farm-house. It is a barytes² mine on a lode in a fault in the Stapeley Ashes, the barytes being of good quality. Galena occurs in occasional spots and splashes, and more rarely in bunches. Traces of copper are rare, and quartz seldom occurs.

Wotherton Mine.—This also is a barytes mine.³ It is situated⁴ at Wotherton, two miles north-east of Chirbury. The vein-stuff contains occasional spots of galena and more rarely of blende. The vein is in a fault and occurs chiefly in the Hagley and Whittery Ashes of the Chirbury (Bala) Series. The workings have been carried to a depth of 143 fathoms.

Bulthy Mine.—This may be mentioned here, although it is situated⁵ in Montgomeryshire, and some distance outside our main area. It is one of those believed to have been worked for lead by the Romans. It lies about two-thirds of a mile north-east of Middletown (6 miles north-east of Welshpool). One ton of galena was got in 1885. Until 1894 it was worked for barytes.⁶

B.S.

¹ New Series One-inch Ordnance Map 165 (Montgomery); six-inch Mont. 38 N.E. Old Series Geological Map 60 S.E. Lat. $52^{\circ} 34' 1''$. long. $3^{\circ} 2' 10''$.

² 'Special Reports,' *op. cit.*, p. 66.

³ 'Special Reports,' *op. cit.*, p. 61.

⁴ New Series One-inch Ordnance Map 151 (Welshpool); six-inch Shropshire 47 N.W. and S.W. Old Series Geological Map 60 N.E. Lat. $52^{\circ} 35' 50''$, long. $3^{\circ} 3' 50''$. New Shaft: lat. $52^{\circ} 35' 52''$, long. $3^{\circ} 4' 0''$.

⁵ New Series One-inch Ordnance Map 151 (Welshpool); six-inch Mont. 16 S.E. Old Series Geological Map 60 N.E. Lat. $52^{\circ} 42' 44''$, long. $3^{\circ} 1' 23''$.

⁶ 'Special Reports,' *op. cit.*, p. 63

PART II.—NORTH WALES.

CHAPTER III.

INTRODUCTION.

In that part of North Wales embracing the counties of Anglesey, Carnarvonshire, Merioneth, Denbighshire, Flintshire and Montgomeryshire, lead and zinc ores occur in the Lower Palaeozoic rocks ranging from Cambrian to Silurian. In Snowdonia the ores are found in rocks of Llandeilo and Bala age; in Merioneth, in the Cambrian rocks of the Harlech Dome and also in the encircling fringe of overlying Ordovician strata. In Denbighshire and Flintshire the chief lodes occur in the Wenlock-Ludlow Series of the Denbighshire Uplands and the Llangollen Syncline, whilst in Montgomeryshire they appear chiefly in the Llandeilo and Bala Beds of the Berwyn Dome. In Anglesey, lead and zinc ores occur in association with the copper ores raised at the Parys Mountain, Mona and Rhôsmynach Mines¹.

The lodes occur almost invariably in fault-planes. In Snowdonia and in Merioneth they are not clean-cut fissures, as the country-rock is often mineralized, and the gangue consists largely of quartz; whereas in the Llanrwst district the lodes are mineralized fault-breccias, with calcite as the principal gangue-mineral. These differences appear to be connected with the different degrees of coarseness of the volcanic materials interbedded with the shales and slates of the two districts.

In Denbighshire and Flintshire the lodes occur in faults and fissures containing a considerable amount of breccia. In all cases the richest parts of the lodes are those where rocks of gritty, ashy, or igneous type form one or both walls. In the shales or slates the veins pinch out. This is in marked contrast with the lodes in Cornwall and Devon, where the lead and zinc ores occur principally in the slates, and become scanty in grits, sandstones and igneous rocks.

In the majority of cases the faults in which the lodes occur are apparently related to movements initiated in early post-Silurian and possibly continued throughout Carboniferous times. The faults are obviously connected in some cases with the strike and dip of the rocks. In the districts of Llanrwst, Carnarvonshire, and Llangynog, Montgomeryshire, the vein system is more complex than usual, probably owing to torsional movements that have affected the rocks in the neighbourhood of some of the large structural faults. It is an interesting fact, however, that the great structural faults of North Wales, such as the Bala Fault and its associates, the Vale of Clwyd Fault, and the Conwy

¹ See forthcoming Special Report on Copper Ores (*Mem. Geol. Surv.*).

Valley Fault, are not mineralized, probably because they contain broad belts of pugged impervious argillaceous material.

The date of mineralization cannot be stated with certainty, but considerations of structure and the relation of the faults and lodes to those affecting the Carboniferous rocks lead us to infer that it was post-Carboniferous and possibly pre-Triassic. In certain cases (pp. 54, 72) it is evident that there were two periods of mineralization, possibly, however, separated by no great interval of time.

The principal ores are galena and blende. In the majority of the lodes both these minerals occur, either in association or in separate strings; while in others one mineral is present to the exclusion of the other. Galena, for example, is the only metalliferous ore at Bwlch-creolen (p. 44), whereas blende occurs alone in one of the Aberllyn lodes, Llanrwst. Cerussite is not common, but has been found in several of the mines, while pyromorphite, mimetite, and hydrozincite are occasionally met with.

As to the associated minerals, iron pyrites is fairly common, and forms the principal constituent at Cae-côch Mine, Trefriw, and at a small mine near the Klondyke Mills, below Llyn-Crafnant (p. 67). Copper pyrites (with malachite) also occurs locally, sometimes in remunerative quantities in veins that have been worked for lead as well as copper; for example, in the Llansannan district and near Dolgelley and Snowdon. Mispickel also is common in the Dolgelley district, though it has not been wrought there. At Craig-rhiwarth, Llangynog (p. 44), a copper-lode is present almost alongside the lead-lode. At Nant-y-blaid (p. 45) copper pyrites has been found as isolated crystals in a vein of pinkish orthoclase, and gold also is said to have been discovered. In the Dolgelley district gold is of frequent occurrence in association with both zinc and copper ores. Bismuth telluride and pyrrhotite are other constituents of these lodes. It is only exceptionally that silver occurs in payable quantities in association with galena, and in the Llanrwst district the general percentage is too low for profitable extraction. In the Llangynog district the galena raised in 1866 averaged about $3\frac{1}{2}$ ozs. of silver per ton. Barytes and witherite occur fairly commonly in the Llangynog district and at the Pennant Mine, St. Asaph; but they have not been found in the Llanrwst, Llansannan, Dolgelley and Snowdon districts.

As regards any zonal arrangement of the ores within the veins, there is no conclusive evidence, owing chiefly to the scattered occurrence of the veins and the shallowness and abandoned state of many of the mines. In the Llanrwst district, where the rocks form a complex syncline pitching north-north-east, a definite arrangement appears to hold good. On approaching the syncline from the east the lodes first encountered carry a preponderance of zinc blende; those beyond, of galena; and those on the west, of pyrites. This order may also occur in any one vein, with increasing depth.

As the majority of the mines in the Llanrwst district are above adit-level, little pumping is necessary. With the exception of the chief mine (New Llangynog or Pengwern), the same conditions are found at Llangynog, Pennant Mine, St. Asaph, and Llanfair Mine, Llanfair-Talhaiarn, were worked below adit-level.

Water, operating water wheels and turbines, is still used extensively as a source of power in the Llanrwst district, and large sums were formerly expended on similar works near Llangynog.

Dressing-plants are, as a rule, of normal type; but at Aberllyn, near Llanrwst, a special type of oil-flotation plant has been installed (p. 62).

In the mountainous Llanrwst district most of the mines are difficult of access. In others, transport is largely dependent upon roads, although Llangynog is served by a branch of the Cambrian Railway.

In Carnarvonshire and Merioneth the processes and plants employed at the various mines for the separation of the ores from their gangue-materials and from each other, and for their further concentration and dressing, are alike in most cases, and are based upon sorting into graded series and upon gravitation. The power used at most of the mines is derived from water, operating turbines or Pelton wheels. Streams have been impounded and lakes increased in area by the erection of embankments across their natural outlets. Llyn-y-parc and Llyn-Geirionydd, near Llanrwst, are natural lakes with artificial extensions, while many of the small lakes, such as Llyn-ty'n-y-mynydd and its neighbours, have been constructed by the impounding of streams. Steam and also suction-gas are employed in the production of power.

The ore, which consists normally of a mixture of galena and blende, is first broken, then passed through crushers, picked on a conveyor-belt, ground between rollers, sized in trommels, and separated in jigs, the slimes being treated on tables and vanners. It is sometimes further dressed in buddles and kieves. The commonest pattern of table is the Wilfley; one mine uses the Sturtevant, and at another an oil-separation plant has been installed.

Underground water presents few difficulties, as most of the mines lie above adit-level. Transport to the rail-head is attended with difficulty on account of the bad state of the roads and of their steep gradients.

The following account of the mines is necessarily incomplete. In the various Mineral Statistics (from 1845 onward) numerous other mines are mentioned, together with their outputs; but as no guide to their situations is given, except the names of the counties, it is now impossible to locate them. Some of the names under which the mines are entered have probably been replaced by others still in use; but in many cases the mines are disused and no information about them is obtainable.

CHAPTER IV.

NORTH WELSH MINES.

MONTGOMERYSHIRE : LLANGYNOG DISTRICT.

In the northern corner of this county, several mines have produced a considerable quantity of ore in past times, though no longer working. The veins traverse Llandeilo beds that contain contemporaneous lavas, ashes, and intrusive rocks.

Llangynog Mine.—Probably the most important of the veins was that worked at the Llangynog Mine,¹ situated on the hill-side about a third of a mile south of Llangynog, 15 miles west of Oswestry.

According to Pennant,² lead-ore was discovered here in 1692, in a vein with a width ranging up to $3\frac{1}{2}$ yards, 2 yards at least being solid ore. It was worked to a depth of 100 yards before operations were stopped by water. The mine had continued in a flourishing state for nearly 40 years. D. C. Davies,³ writing in 1881, stated that it had then been in work for about 150 years. It was being worked for lead and calamine about 1797 when visited by Arthur Aikin,⁴ the raw produce being sent to the foundries near Ruabon. In 1809 it was apparently dormant, but was described by Westgarth Forster⁵ as being, while it lasted, perhaps the richest vein of lead-ore yet discovered in this island. It was worked again at later dates, however, 60 men being employed in 1845–46. From 1852 to 1860 inclusive it appears to have been known and worked as the Chirk Castle Mine, after which it was called the Llangynog Ltd., East Llangynog, and New Llangynog or Pengwern Mine. On the six-inch ordnance map it is named South Llangynog Mines.

The mine was last worked in 1877 or thereabouts by the Dyke Dennis Co., Ruabon; but since that date the Vieille Montagne Co., in 1892–4, tested the tip-heaps for lead and zinc ores.

The chief vein trends east and west, along a faulted junction between an intrusive 'neck' of rhyolite, with attendant lava, on

¹ New Series One-inch Ordnance Map, 136 (Bala); six-inch, Montgomeryshire 4 S.E.; Old Series One-inch Geological Map, 74 S.W. Lat. $52^{\circ} 49' 10''$, long. $3^{\circ} 24' 15''$.

² 'Tours in Wales,' vol. iii, 1810, p. 172.

³ 'Metalliferous Minerals and Mining,' 8vo, Lond., 1881, p. 203.

⁴ 'Journal of a Tour through North Wales, etc.,' 8vo., Lond., 1797, p. 14.

⁵ 'A Treatise on a Section of the Strata commencing near Newcastle upon Tyne and concluding on The West Side of the Mountain of Cross-Fell. With Remarks on Mineral Veins in general, and Engraved Figures of some of the different species of those Productions, &c.' Newcastle, 1809, pp. 67–8.

the north, and Llandeilo slates and sandy shales on the south. To the east the rhyolite is thrown against the Llandeilo beds by a north-and-south fault. Between the 66- and the 130-yard levels in the centre of the mine the vein hades northward at approximately 25° from the vertical.

The slate or 'blue-stone' adjacent to the fault plane on the south side of the lode apparently underlies the igneous rock on the north side in the deep, the top of the slate on that side (which is near the surface at Rock and Cady's Levels at the east end of the mine) descending westward to below the 130 yard level beneath the Tanat Valley.

T. H. Cope¹ remarks that some of the higher levels show no igneous rock beyond [south of] the fault, though the spoil-heaps of others nearer the valley bottom prove the piercing of the fault-lode, and that beyond it rhyolitic lava was found in force. This, he states, is confirmed by the open-cast and day-level on the lode at Ty-newydd, where the fault hades south, the footwall carrying a buried extension of the lava-sheet dipping south-west at a low angle.

West of the Chirk Castle Shaft a cross-course, hading eastward, crosses the vein some distance west of the centre of the mine.

The ore consisted of argentiferous galena and blende, and there was in addition a little copper pyrites. The gangue was chiefly crushed igneous rock, slate, quartz and calcite, a heap of which materials may be seen near the old engine-house close to the Boundary Shaft. Barytes and witherite also occurred sparingly. The fault, showing slate and 'granite' crushed together, is visible at the old Pen-y-pare Level, about 80 yards east of the ruins of Ty-newydd. Another level on the lode, close by, is filled in. A second vein, south of and parallel to the main vein, was reached by a cross-cut driven by the old company. This south lode was 4 or 5 inches thick, and a width of $2\frac{1}{2}$ inches of pure galena was seen in the day-level, on the mountain side above the old pit-head, 60 yards south of the Ty-newydd barn.

The chief shafts on the main lode are : Chirk Castle (filled in), Powis or Boundary, and the New Incline Shaft. The two former are vertical. The Chirk Castle Shaft lies west of the Boundary Shaft. These shafts are situated about 450 yards south-west of Llangynog Bridge over the Tanat. The vein was worked down to the top of the slate or blue-stone. A day-level, commencing at the turnpike road at Hen-stent, runs through west-south-westward to the Boundary Shaft. Above this level, at the eastern end of the mine, are Cady's and Rock Levels; farther east, and higher up, is the Eastern Level, in barren ground. To the west of Cady's Level an inclined plane follows the vein down nearly to the 66-yard level.

¹ T. H. Cope, 'On the Igneous and Pyroclastic Rocks of the Berwyn Hills,' Cope Memorial Volume, edit. by C. B. Travis, *Proc. Linc. Geol. Soc.*, 1915, p. 50.

In the main part of the mine, farther west, there are levels at 66, 70, 90, 110 and 130 yards. The 60-yard level connects the Chirk Castle with the Boundary Shaft and runs some distance farther eastward. The 70-yard level is driven from the Chirk Castle Shaft; whilst the 90- and 110-yard levels run from beneath the Boundary and Chirk Castle Shafts westward beneath the Tanat Valley, which at this end of the mine takes a south-west and north-eastward direction. The 130-yard level is approached by a sump from the 110-yard level and by the new incline plane of the new company. The top of this incline lies about 60 yards south-south-east of the Chirk Castle Shaft, and touches the slate at the 130-yard level, at the west end of which ore was stoped. Ore was got in 1877 from the 110-yard level, the vein varying from 4 feet to 18 inches wide, and yielding ore at $1\frac{1}{2}$ to 2 tons per fathom. At the end of the 90-yard level, as far west as the Pengwern Shaft, the vein was 1 foot thick, in poor spar and stone. Pengwern Shaft, which is situated on the north bank of the Tanat, fell short of the horizon of the 66-yard level in the mine. A short level was driven on this side of the river to cut the supposed continuation of a stringer that leaves the main vein at the Chirk Castle Shaft, but failed to achieve its object.¹ West of these two shafts (New Incline and Chirk Castle) there are two adits at stream-level.

In the old days power was obtained from water-wheels and steam. A sum of 50,000*l.* to 60,000*l.* was spent in the construction of a dam at Llyn-y-mynydd (the Mountain Lake) and bringing water thence by an open leat to work the water-wheel. A second pumping-engine was situated in the wood west of the Chirk Castle Shaft.

The output at one time was large. Before Pennant's day the mine yielded 4,000 tons of ore annually. The ore was sold at £7 a ton and smelted on the spot, and brought in a clear revenue of 20,000*l.* a year. From 1852 to 1880 the mine furnished returns of ore continuously, but it is said to have been closed in 1877. In this period it yielded 6,864 tons of galena, the greatest annual productions being in 1858, with 850 tons of galena; in 1865, with 538 tons of ore, yielding 992 ozs. of silver; and in 1866, with 607 tons of ore, yielding 2,127 ozs. of silver. The mine was closed owing to the low price of lead and trouble with workmen. It was at that time necessary to cart the ore to Oswestry, or to the Shropshire Canal at Pool Quay, 4 miles north-east of Welshpool. Since that date the Tanat Valley Railway has been constructed, with its terminus at Llangynog.

Within a mile to the north-west and north of Llangynog lie the old mines of Ochr-graig, Cwm-orog and Craig-rhiwarth. At all these mines the lodes have been most productive in the hard rocks (either intrusive or lavas); when the lodes pass into the

¹ The above details are taken from a working plan in the possession of Mr. H. Watson, of the Berwyn Granite Co., Llangynog.

slaty rocks they become less productive, and in the shales are usually barren.

Ochr-graig Mine.—This is situated¹ on the hill-slope north of Llangynog Station, on an east and west vein and fault that hades northward and throws intrusive rock on the south against Llandeilo beds on the north. The vein was reached by two adits, the one 25 yards above the other, driven into the hill-side, and levels were opened out along the vein for one or two hundred yards, the vein being worked to the surface. The lower adit is close to the blacksmith's forge a little over 100 yards north-west of the station, the other is farther east. Galena and blende, with a gangue of calc-spar and quartz, are to be seen on the tip-heaps from the levels. A little copper pyrites also is present. The seams of ore are stated to have been more regular than at Cwm-orog.

Cwm-orog Mine.—This mine, which is situated² to the east of the Bala road, about three quarters of a mile north west of Llangynog, yielded barytes and witherite³ as well as lead and zinc. The vein carrying galena and blende hades northward and runs slightly north of east, chiefly in igneous rhyolitic rock, but eastward it passes into Llandeilo slates and lavas. It may be the vein formerly worked at the Craig-rhiwarth Mine.

Four day-levels⁴ have been driven southward into the hill-side to the vein. The lowest, or No. 3, reaches the barytes lode, which is an independent vein on a nearly north-and-south line. The level reaches the lead-vein at a distance of 82 feet and then turns eastward along the vein for about 47 feet to an old shaft now full of water. No. 2 Level, 119 feet higher, is above the outcrop of the barytes-lode. The third, or old No. 2, is situated farther south. The highest, or No. 1 Level, 60 feet above No. 2, is 10 yards long; good galena was found where it cut the lode, which here appears to pass beyond the vertical and to change its hade, slate coming in on the hanging-wall. Hereabouts the vein has been stoped to the surface, but no payable ore occurs below the level at this point, although it has been sought.

Usually both walls of the lode are vaguely defined, the hanging-wall being the more regular. Galena was found in fairly prolific bunches up to 18 inches in thickness, and the blende occurred separately, mixed up with broken rock. There was no difficulty with water.

The ore, like that of some of the other mines in this area, was formerly sent by road to Llanfyllin. The Vieille Montagne Co. took possession about 1900 and operated for three years; later the mine was worked by Messrs. Newman Ogle Son and Grace.

¹ Maps as for Llangynog Mine.

² Mont. 4 N.E. Lat. 52° 50' 5", long. 3° 24' 25".

³ 'Special Reports on the Mineral Resources of Great Britain,' vol. n, Barytes and Witherite (*Mem. Geol. Surv.*), ed. 2, 1916, pp. 73-4.

⁴ Details from a plan in the possession of Mr. H. Watson, Berwyn Granite Co., Llangynog.

who dispatched the ore by the Tanat Valley Railway. An aerial ropeway, which took the place of an old tramway from No. 2 Level, carried the ore down to a dressing-plant on the main road. The plant was dismantled about 1912. The mine was last worked for lead in 1907-9, when 13 tons of galena, which yielded 53 ozs. of silver, were obtained. Previously, in 1900, 30 tons of galena averaging 80 per cent. lead, and 25 tons of blende averaging 46 per cent. zinc, were obtained by the Vieille Montagne Co.

Craig-rhiwarth Mine.—This mine, which is situated¹ farther east, ceased work entirely about 30 years ago. Galena, blende and copper were got, the copper-lode being near, but oblique to, the lead-lode, and running some degrees south of east. The copper-ore occurred in brassy strings in a lode about 2 yards wide.

The main lode averaged about 3 yards in width, in which galena and blende occurred sometimes separately, sometimes mixed together. Brownish-yellow barytes² and witherite also occurred, but not in sufficient amount to pay. The lode was only productive in the beds of porphyritic igneous rock that alternate with the slates. Between 1848 and 1862 the mine was worked sporadically and yielded 641 tons of galena, 245 tons having been got in 1859.

About half a mile east of Craig-rhiwarth the hanging valley named Cwm-lan-afon, which falls southward into the Tanat Valley, has been the scene of further mining operations, chiefly on two fault-lines that cross the mountains eastward to the Rhaiadr Valley,³ where they were worked for lead at Craig-y-mwn and Nant-y-blaidd (p. 45). In Cwm-lan-afon the Vieille Montagne Co. made numerous trials on these faults with little success; the old tips from the adits consist chiefly of cleaved shale, rhyolitic lava (or ash), and quartz spar. At a spot named Cobbler's Gate, 200 yards from Cwm-lan-afon Farm, old clusters of lead slag mark the position of an old smelting-site; the ore may have been brought from either the Cwm-orog or the Craig-y-mwn direction.

Craig-ddu Mine.—This mine, which is situated on the south-eastern side of Craig-ddu (nearly $1\frac{1}{2}$ miles south of Llangynog and about a mile north-east of Hirnant), is an old work, opened on a vein and fault trending east-north-east and west-south-west and throwing Llandeilo beds on the south against ashes and shales on the north. Lead-ore and barytes were raised by a shaft on the vein. Farther west, within half-a-mile to the north-west of Hirnant, there is an old mine named Clochnant, on the line of the same fault.

Bulch-creolen Mine.—This mine⁴ worked a lode occupying the fault that ranges south-eastward from Cwm-lan-afon past Pen-y-

¹ Mont. 4 N.E.

² 'Special Reports,' *op. cit.*, p. 74.

³ Mont. 5 N.W.

⁴ New Series One-inch Ordnance Map 136 (Bala); six-inch Montgomery 9N.W. Old Series Geological Map, 74 S.W.

bout (in the Tanat Valley) to Bwlch-creolen, a pass on the west side of the hill named Dŷs-Eithin, about four and a half miles south-east of Llangynog. At this point the lode traverses Caradocian (Bala) sandstones and shales. It carries galena and barytes, the galena occurring in a gossan of fault-breccia and calc-spar.

The vein was worked over a distance of 55 yards by a shallow adit, opening on the hill-side on the course of the lode. About halfway along the workings a small east-and-west fault throws down northwards. The vein was also worked from a deep adit opening south of the shallow adit close to the office near the road to Pen-y-garnedd.

About $2\frac{1}{2}$ chains east of the mouth of the shallow adit a short level runs northward to a counter lode, trending north-westward and worked for 22 yards.

The ore was run eastward from the office by a tramway for a distance of little over 300 yards, and transferred to an incline that crossed the Pen-y-garnedd road southward to dressing-rooms situated in the valley bottom.

No returns of lead-ore have been made from this mine since 1882, when 14 tons 14 cwts. were obtained.

Nant-y-blaidd Mine.—This is situated¹ in the Rhaiadr Valley, about 200 yards west of Ty'n-y-llwyn. The fault carrying the lode runs south-south-westward from the valley and then swings south-westward in the direction of Cwm-lan-afon. It hades westward, throwing Llandeilo shales and slates on the west against the calcareous and fossiliferous Llandeilo ash, which dips south-eastward, on the east. Three levels have been driven along the lode; in the upper the phenomena of faulting are evident, and there is much quartz veining. Besides galena, chalcoppyrite occurs, in a gangue of pale pinkish orthoclase. Sulphur and gypsum were present also, as small crystals. It is locally reported that the lode yielded gold, amounting to about 2 ozs. per ton.

A little over 100 yards south of Ty'n-y-llwyn a broad vein of quartz and crushed rock, on the line of fault that throws ash against cleaved shales, contains a little lead-ore and pyrites. It has been prospected by several trial-adits. No returns of ore have been made from Nant-y-blaidd.

Craig-y-morn Mine. The vein here, said to have been discovered in 1769, was worked intermittently for more than a century before being abandoned about 1911. Aikin² states that it was filled with water when he visited the region, but that a level of considerable length was to be driven to drain it. He quotes Pennant as stating that the vein was $3\frac{1}{2}$ yards thick and was

¹ New Series One-inch Ordnance Map 136 (Bala); six-inch Montgomery 5 N.W. Old Series Geological Map, 74 S.W.

² 'Journal of a Tour through North Wales, etc.,' *Svo., Lond., 1797*, pp. 14, 15.

worked to a depth of 100 yards before it became choked with water. It yielded annually 4,000 tons of ore. The Vieille Montagne Co. held it for a short time about 1900. The mine is situated¹ near Tan-y-graig, in the Rhaiadr Valley, in a belt of fractures, one of which trends south-westward towards Cwm-lan-afon, whilst the other takes a more westerly course. The faults throw slates and shales against interbedded igneous rocks (rhyolitic lavas). There are four east-and-west lodes, one west-north-west and east-south-east lode, and one north-and-south. Several levels have been driven into the hill-side along and to the lodes, in which the phenomena of crushing and brecciation common to faults are apparent. The ore occurred in bunches; we were informed of one 3 feet 6 inches in thickness and 25 yards in length. In one level, 300 yards in length and inspected in 1913, the hanging-wall on the west is strongly slickensided, and a considerable amount of galena and blende was visible in the gangue, which consists of crushed shale, igneous rock, quartz, and calcite, with some pyrites. The cross-cut to No. 1 lode has cerussite and galena, with barytes on the footwall. Witherite also occurs in the mine.

In the old days the ore was dressed and then carted to Porth-y-waen for transport by rail. Nowadays it could be put on rail at Llanrhaiadr-ym-Mochnant. No official returns of output have been made.

DENBIGHSHIRE : LLANFAIR-TALHAIARN-LLANSANNAN DISTRICT.

Several mineral veins that occur in the Llanfair-Talhaiarn and Llansannan district,² six miles south of Abergele and 8 to 10 west of Denbigh, have been worked for lead and copper. These veins are situated in the broad deeply-trenched plateau of Silurian rocks (Wenlock-Ludlow Shales) lying between the vale of the Conwy and the Vale of Clwyd, a remote region in which the only means of communication is by road.

Nant-y-plwm Mine.—This mine is situated³ on a north-and-south vein that crosses a dingle (Nant-y-plwm), tributary to the river Aled, about half a mile west of Llansannan. There is an old adit on the right bank of the nant, a few yards above stream-level, and on the top of the valley wall, on the north or left side, are several small shafts above a narrow rift on the course of the vein. In the waste from the level the gangue of brecciated mudstone and shale, cemented by calcite and what may be dolomite, contains galena, and also green copper carbonate and ferric oxide, apparently derived from copper pyrites.

¹ Mont. 5 N.W.

² New Series One-inch Ordnance Map, 107 (Denbigh); Old Series Geological Map 79 S.W.

³ Six-inch Denbighshire 12 N.E.

From the adit the ore was conveyed to the road near Llanfannan by a tramway, laid along the dingle. The mine is said to have been closed 26 years ago. No official returns of ore were made.

Within a mile and a half to the north and north-east of Llanfannan are the old copper-mines of Bryn-nant-llech and Dyffryn-Aled.¹

Near Llanfair-Talhaiarn there are three mines: two, named Bron-heulog and Ty'n-y-ddöl, north of the river Elwy, the other, named Llanfair, south of it.

Bron-heulog Mine.—This mine, lying a mile north-east of the village and 700 yards east-north-east of Bron-heulog,² was opened on a vein trending south-west and north-east. The vein was worked for lead up to about 30 years ago. No plans are available. The Mineral Statistics give the output of Ty'n-y-ddöl³ (the name of a farm-house about a mile east of Bron-heulog) for 1886 as 3 tons of lead-ore. This is apparently the last date at which lead was raised here.

Llanfair Mine.—More information is available about this mine,⁴ plans of which were deposited at the Home Office in 1907.

The main or Morgan Lode trends almost north and south and underlies westward. It was worked from three shafts, their names, in order from north to south, being Morgan's, North, and South Shafts. Morgan's Shaft lies about 130 yards east of a farm-house. The North Shaft is 50 yards south-south-west of Morgan's; the South Shaft lies 35 yards farther south. The mouth of the adit-level is situated on the hill-side, 32 yards west of Morgan's Shaft, in which it is 40 feet below the surface.

Morgan's Shaft, near which there is a footway, is vertical to a little below the 60-fathom level, which is actually at 370 feet below the surface. It passes through the footwall of the lode at 120 feet, and cross-cuts are set off to the lode at 10 fms. (101·9 ft.), 20 fms. (154·3 ft.), 30 fms. (203·8 ft.), 40 fms. (260 ft.), 50 fms. (310·6 ft.) and 60 fms. (370 ft.). There are lower levels at 70 fms. (425·2 ft.), 85 fms. and 100 fms.

From the 120-foot point in Morgan's Shaft the lode was traversed by an incline, trending slightly north of west, to a depth of 85 fathoms, and most of the work was done south of this incline. The inclination of the lode, as it was followed down was found to vary as follows:—58·2°, 58·34°, 54·5°, 52·09° and 57·15°.

The North and South Shafts go down to the 10-fathom level.

The two higher levels in the mine, viz., the 10- and 20-fathom, are short; but lower levels are longer, that at 50 fathoms being 165 yards, that at 85 fathoms being 300 yards, in length; the

¹ To be described in a forthcoming 'Special Report' on Copper Ores.

² Denb. 7 N.E.

³ The six-inch map, Denb. 7 N.E., shows two levels within 200 yards north-west of the house.

⁴ Denb. 7 S.E. Lat. 53° 13' 7", long. 3° 35' 37".

latter, however, meanders about as if it does not everywhere follow the lode—part of it, in fact, being on the New Vein mentioned below.

Towards the southern end of the mine the lode has been worked between the 30- and 60-fathom levels, the lode being nearly vertical from 30 to 40 fathoms, below which it is inclined at about 60°. It is here accompanied by a flucan or clay-course on the hanging-wall at the 50- and 60-fathom levels; similar flucans were met in cross-cuts to the west off the 60-fathom level. A lode with similar hade, proved at the 50-fathom level, lies a little distance east of the Morgan Lode in this part of the mine.

The main or Morgan Lode is accompanied on its western side by a New Vein, trending magnetic north and south. This has been worked at the 70- and 85-fathom levels, and was explored about the years 1903–5 at the 100-fathom level, when blende was got in a sump off a cross-cut from the 85-fathom level. Stoping was done below the 70-fathom level in the last years of the life of the mine. A little copper-ore was found at one point in the 85-fathom level. An exploratory cross-cut was made westward for 50 yards from the 70-fathom level, apparently without success; but a cross-cut driven eastward for 195 yards from the 60-fathom level encountered near its termination some north-and-south joints with galena.

The concentrating-plant was situated about 50 yards north-west of Morgan's Shaft.

Small quantities of galena were obtained here from 1891 to 1896 inclusive, the ore averaging 76 to 80 per cent. of lead. Returns were made for 1902 and 1903 also, amounting to 22 tons; 4 tons of blende were got in 1896, and 21 in 1902, averaging 48 per cent. of zinc. Mixed zinc and copper ore was raised in 1903, amounting to 31 tons and yielding an average of 27 per cent. of zinc and 2 tons of copper. About 47 tons of copper-ore yielding 5 tons 10 cwts. of the metal were raised between 1895 and 1897, whilst 84 tons yielding 8 tons of copper were got in 1902.

To the south-east of the South Shaft there are a few old shafts, and also an adit that opens out on the hill-side 80 yards away. These may be on another north-and-south lode.

DENBIGHSHIRE: SUBSIDIARY OCCURRENCES.

Llandegla.—An unsuccessful search for lead-ore in workable quantities was made in 1910 in crushed and quartz-veined Bala (Ashgillian) Shales, on a fault-line about 130 yards east of Hafod-Bilston¹ (a mile south-east of Llandegla). The fault lies parallel to and 100 yards east of the great Bala Fault, which passes in a south-south-westward direction beneath Hafod-Bilston. A level²

¹ Hafod-Puleston.

² New Series One-inch Ordnance Map, 121 (Wrexham); six-inch Denbighshire 27 N.E. Old Series Geological Map, 74 N.E. Lat. 53° 3' 6", long. 3° 10' 51".

runs southward from the stream-bed for about 24 yards, and has a small sump sunk at its end. There is an old shaft also, sunk on the north side of the stream, and a second level runs in that direction. Farther south, on the line of the same fault, levels have been made in the belt of crushed rock that crosses the westward-descending gullies on the hill-side east of Trefydd-bychan and Graig farms.

Llangollen.—On the steep northern slope of Craig-y-ddualt, about $1\frac{1}{2}$ miles south-east of Llangollen, traces of galena have been found in two barytes-veins, one of which trends north-north-eastward, the other northward. Both appear to have been worked by open-cast. The first vein crops out about 100 yards south-east of Ty'n-y-celyn; the other lies about 70 yards farther east. A cross-cut day-level,¹ 40 yards south of the farm-house, has recently been driven to the western vein for the purpose of working both for barytes.²

FLINTSHIRE: ST. ASAPH DISTRICT.

In this county the only mine at which recent operations are likely to lead to an output of lead-ore from the Pre-Carboniferous rocks is the Pennant Mine, near St. Asaph. Of late years it has yielded only barytes and witherite.

PENNANT MINE, ST. ASAPH.

St. Asaph Zinc, Lead, and Baryta Co., Ltd., Pennant Mines, Rhualt, St. Asaph.

Situated on the south side of the Holywell road, 3 miles east of St. Asaph. The New Engine Shaft is 180 yards south-east of Pennant, the manager's house.

Maps.—New Series One-inch Ordnance, 107 (Denbigh); Old Series Geological, 79 S.W.; six-inch, Flintshire 5 S.W. Lat. $53^{\circ} 16' 21\frac{1}{2}''$. Long. $3^{\circ} 22' 12''$.

The vein worked here cuts the Wenlock Shales, which dip more or less southward. It trends a few degrees south of east, and has a varying underlie. It has been worked over a distance of about 500 yards, but has been traced somewhat farther; at the time of our visit in 1919 the mine was partially flooded.

The shafts lie on the back (north) of the vein. The deepest is the Old Engine Shaft, 103 yards deep, off which there are levels in the vein at 20, 40 (adit), 60, and 80 yards depth, with a short one at the bottom. The shaft lies 160 yards east-south-east of the New Engine Shaft, which is an old shaft re-fitted, 80 yards deep, with levels at 40, 60 and 80 yards depth. A steam-pump

¹ New Series One-inch Ordnance Map, 121 (Wrexham); Old Series Geological, 74 N.E. Six-inch, Denbighshire 39 N.E. Lat. $52^{\circ} 57' 29''$, long. $3^{\circ} 8' 24''$.

² 'Special Reports on the Mineral Resources of Great Britain,' vol. ii, Barytes and Witherite, (*Mem. Geol. Surv.*), ed. 2, 1916, p. 73.

has been installed at the New Engine Shaft to unwater the mine, but some stoping has been done recently at adit-level. This adit (the 40-yard level) runs from the east end of the mine to a point about 170 yards west of the New Engine Shaft, and then turns northward to daylight close to the road-bend south of Pennant House. On this 170-yard section there are two old shafts. The Bryn-gwyn Shaft, 80 yards deep, lies about 100 yards east of the Old Engine Shaft, with levels at similar depths. This shaft has run in.

On a plan, dated 1889 (in the possession of the manager), the lode is shown as underlying southward at the Old Engine Shaft between the depths of 20 and 60 yards; but at the New Engine Shaft it is shown with northward underlie.

On the north side of the lode there is a stringer trending east-north-eastward. On the south side there is a South Lode with similar trend; this has been explored by a level at 60 yards depth.

The westward continuation of the main lode has been sought by two levels; the first being situated about 400 yards north-east of the smithy at Rhualt, the second in the dingle north of the road-bend 700 yards west of Pennant. Neither attempt was successful, and if the lode continues to hade northward, as at the New Engine Shaft, both the levels were wrongly sited.

The vein is from 9 to 10 feet wide and in recent years has been worked chiefly for barytes and witherite.¹ In future it is hoped to raise a considerable proportion of lead, which is expected to be met with in depth beneath the barytes 'cap.' From notes entered on the plan and section, dated 1889, we gather that at about that date lead-ore was being stoped west of the Old Engine Shaft between the 20- and 60-yard levels, but that the ground east of the shaft had been cleaned out. Below the 80-yard level the ground was virgin.

In the centre of the vein there is a concentration of galena, and fairly good bunches occurred with barytes at adit-level. Galena is present in small amounts in the gangue also, which consists mainly of barytes, with zinc blende in aggregates of all sizes. Witherite is fairly common at adit-level, and also in pockets at lower levels; some is said to come from the lowest level. It usually occurs by itself, associated with the gangue, and will be treated separately.

"The refuse-heaps from the old lead-workings are extensive, and contain much zinc-blende, barytes and witherite. These dumps, $\frac{1}{2}$ mile in length and about 100 feet wide, are considered to have a total contents exceeding 100,000 tons. In some places they are being worked over for barium-minerals and for what little galena can be got."¹ The relative proportions of the minerals in the dumps have not yet been determined.

¹ 'Special Reports on the Mineral Resources of Great Britain,' vol. ii. Barytes and Witherite (*Mem. Geol. Surv.*), ed. 2, 1916, p. 67.

A grinding-mill and dressing-plant have been erected in the valley, where there is a plentiful supply of water. New oil-driven machinery had been installed and had commenced running in Sept. 1919, when 10 men were at work. The separation of the blende and barytes is difficult. The first jig gives galena and barytes together, which are separated by hand-jigging; the blend is carried on with the barytes.

An output of lead-ore was last returned from the mine in 1890-1891, only 9 tons being got. At an earlier period, 1874-1883 inclusive, 141 tons were obtained, including 40 tons in 1877. Still earlier, *i.e.*, before 1870, the output was higher, 137 tons being got in each of the years 1864 and 1865.

B. S.

CHAPTER V.

NORTH WELSH MINES—(*continued*).

MERIONETH.

GENERAL DESCRIPTION.

In this county there are three principal districts where lead and zinc ores are being worked: (1), Bwlch-y-plwm, near Penrhyndeudraeth; (2), the Ffestiniog Valley; and (3), the neighbourhood of Dolgelley.

In the Dolgelley district the country-rock consists of Cambrian and Ordovician slates. At the other localities it is volcanic rock and slates of Ordovician age.

At Bwlch-y-plwm there are many lodes, which course respectively in a general direction of either north and south or east and west. They are all greatly brecciated and cemented with calcite and quartz, the ore being principally galena, which occurs as large lumps. There is also some pyrites; but blende was observed only in the north-and-south lodes.

In the Ffestiniog Valley the lodes course nearly east and west, and consist of quartz-cemented breccia containing streaks and veins of blende, while at Gamallt, in the same district, the quartz cements together the silicified volcanic agglomerates and ashes. The ores are galena, blende, copper and iron pyrites, and the blue and green carbonates of copper. Recent assays are said to show small values of gold. There have been repeated movements along the lode, and also re-mineralization, the ores of copper having been first developed and those of lead and zinc last.

In the Dolgelley District the lodes were worked primarily for gold, which occurs in the native state, both alone and also in blende. The blende was rejected, and thrown onto the waste-heaps, where it remains. Some lodes contained mixed sulphides, including galena, blende, chalcopyrite, and mispickel, while in addition pyromorphite, orpiment, and mimetite have been recorded.

DETAILS OF MINES.

BWLCH-Y-PLWM MINE, PENRHYNDEUDRAETH.

Union Zinc Mining Co., Ltd., 19, High Street, Portmadoc.

Shafts and levels about a quarter of a mile east of Llanfrothen Church, and 3 miles by road from Penrhyndeudraeth Station (Cam. Rys.).

Maps.—New Series One-inch Ordnance, 119 (Snowdon); Old Series Geological, 75 N.E.; six-inch, Merioneth 11 N.W.

The country-rock consists of sediments of Ordovician age.

At this extensive mine, from which large quantities of lead ore have been obtained, there are seven lodes, of which only two are worked, one coursing east and west, the other north and south. The east-and-west lode, or Main lode, underlies north at about 45°, and varies from 3 inches to 6 feet in width. The galena occurs in bunches, the lode-stuff being greatly brecciated and cemented, partly with calcite but mainly with quartz. There is some pyrites, but no blende has been observed. The hanging-wall is good; the footwall, however, consists of soft rock.

The North-and-South Lode underlies east at 80° from the horizontal, and ranges from 6 inches to 6 feet in thickness. The gangue consists of 'hard rock' (greenstone), which has been shattered by movement and cemented with calcite and quartz. Galena and blende, with some copper pyrites, are the principal ores. There is much pink quartz in parts of the lode.

The adit has been driven eastward for a distance of 600 yards; at a point 200 yards from its mouth there is a shaft, 25 yards deep, with a sump; 50 yards farther east is another shaft, of 12 yards depth. There are five levels above the adit.

The recorded output of lead-ore for various years between 1849 and 1875 amounted to 355 tons, from which 285 tons of lead were obtained by smelting. In 1874, 2,150 ozs. of silver were got from 112 tons of lead. In Oct. 1919 there were about 1,000 tons of mixed ore in stock.

MOELWYN MINE, BLAENAU FFESTINIOG.

Union Zinc Mining Co., Ltd., 19, High Street, Portmadoc.

Levels situated in Nant-ddu, on the eastern lower slopes of Moelwyn-bâch, and about 2 miles south-west of Blaenau Ffestiniog.

Maps.—New Series One-inch Ordnance, 119 (Snowdon); Old Series Geological, 75 N.E.; six-inch, Merioneth 3 S.E.

The country-rock consists of Ordovician sediments, felspathic ashes and felstone.

There are said to be six lodes, but in 1919 work was being done on only three. These lodes course nearly east and west, and dip north at 5 in 7.

Lode No. 1, which lies near Llyn-Stwlan, nearly a mile to the north-west of the works in Nant-ddu, ranges in width up to 7 feet, but not much work was being done on it in 1919.

Lode No. 2, which averages about 20 inches in thickness, consists of a quartz-cemented breccia with streaks and veins of brown zinc blende. Much of the lode is of low grade. The ore is mined by stoping along the footwall, which is very ill-defined and contains stringers here and there of blende. It is all removed and shot down the winze. The hanging-wall is better defined and shows slickensided rock.

Lode No. 2 is worked along four levels, driven into the southern side of Nant-ddu, the first at an altitude of 842 feet

above O.D., the second at 932 feet, the third at 1,008 feet and the fourth at 1,072 feet.

The main level has been driven westward for about 1,300 yards, but not along a lode. It runs 400 yards north of Lode No. 2, which was to be reached by a cross-cut, driven at a level of about 700 feet O.D.; but as the distance between the two would take three years to penetrate by hand-labour, the scheme has not been carried out.

At the edge of the second platform on Lode No. 2 the ore is hand-picked and heaped, and the gangue rejected. Both are thrown down a slope to the trams, which convey them either to the mills or to the dump.

The dressing-plant adjoins the mills, which are situated in front of the main level, beside the Ffestiniog Narrow Gauge Railway.

There are no figures available as to the richness of the ore or the capacity of the plant.

In Oct. 1919 there were some 1,700 tons of zinc blende in stock, and several thousand more in sight.

GAMALLT MINE, FFESTINIOG.

Union Zinc Mining Co., Ltd., 19, High Street, Portmadoc.

Levels in the Gamallt Valley, about half a mile west of Llynau-Gamallt, and $2\frac{1}{2}$ miles by road and mountain track east-north-east of Ffestiniog.

Maps.—New Series One-inch Ordnance, 119 (Snowdon); Old Series Geological, 75 N.E.; six-inch, Merioneth 12 N.E. and 4 S.E.

The country-rock consists of volcanic agglomerates and sediments of Ordovician age.

The lode courses east-north-east and west-south-west, underlies south-south-east at about 55° from the vertical, and is in places as much as 6 feet wide. The gangue consists for the most part of quartz cementing brecciated ashes and silicified volcanic agglomerates. Galena, zinc blende, copper and iron pyrites, with some malachite and azurite, constitute the mineral assemblage of the lode. Some recent assays are said to have indicated not more than .5 per cent. of copper, but up to 17 dwts. of gold per ton. The ore consists principally, however, of galena and blende.

There is much evidence of repeated movement and fracturing along the lode, and of successive infillings by mineral matter. Parts of the ore show pyrites and chalcopyrite in a quartz gangue that has been brecciated and afterwards cemented with growths of blende and pyrites. Calcite is comparatively rare.

A level has been driven along the lode near the hanging-wall, but the footwall is not exposed in it. A second level enters the mountain side at a slightly higher position and a few hundred yards nearer Llynau-Gamallt. A third level, near the Llynau, has not been used for many years, but the lead-ore there is

reputed to be of high grade: the lode is 3 feet wide and averages 12 per cent. metallic lead, but transport difficulties have hitherto rendered the profitable working of this level impossible.

TYDDYN-GWLADYS MINE, TRAWSFYNYDD.

(Idle.)

Old levels and shafts in the steep western bank of the Afon Mawddach, $1\frac{1}{4}$ miles north of Pont-ar-Eden and about $6\frac{1}{2}$ miles by road and track from Dolgelley.

Maps.—New Series One-inch Ordnance, 135 (Harlech); Old Series Geological, 75 S.E.; six-inch, Merioneth 27 S.E.

The country-rock consists principally of greenstone, but in part of sediments of Cambrian and Ordovician ages.

On the old geological map two nearly parallel lodes are indicated, coursing a little north of west. They are said to dip about north at from 60° to 80° , and to range in thickness from $3\frac{1}{2}$ feet to 6 feet.

The chief ore was galena, which contained low values of silver. Formerly there was a large output, but the mine has been idle for many years, and is now flooded. The gangue is mainly quartz, and contains small values of blende, chalcopyrite, mispickel and iron pyrites, and also traces of gold. The lode may be continuous with another formerly worked on the eastern side of the valley at the Cwm-eisen Mine.

The mine was worked by three levels and a shaft. The old workings above adit extend westward from the valley of the Afon Mawddach through the mountain to the valley of the Eden. Much work has been done below adit also, and the reserves at depth are held to be small.

GWYN MINE, TRAWSFYNYDD.

(Standing.)

United Kingdom Minerals Co., Alderley Edge, Cheshire.

Shafts and levels situated about half a mile north-east of the confluence of the Afon Gai with the Afon Mawddach, and 8 miles by road and track from Dolgelley.

Maps.—New Series One-inch Ordnance, 135 (Harlech); Old Series Geological, 75 S.E.; six-inch, Merioneth 27 N.E.

The country-rock consists of Cambrian and Ordovician sediments, with intrusive sills and dykes of greenstone.

The principal lode is accompanied by many parallel lodes. It courses 20° north of east, underlies north at 30° from the vertical, and attains a width of 36 feet. The lode is said to have been worked upon for a quarter of a mile and its outcrop traced for nearly $1\frac{1}{2}$ miles. At both ends it breaks up into a series of small shoots, which branch out fan-wise. It is shifted by several

faults and on the west has not been traced westwards of a boundary-fault. The gangue consists mainly of quartz, including eyes and occasionally large 'horses' of country-rock. The lode-minerals include chalcopyrite, pyrites, mispickel, and large patches of galena and zinc blende. Gold in important quantities has been won at this mine—in fact the mine was for many years the principal producer of Welsh gold. The metal occurs in the form of fine grains disseminated through calcite and blende, and also as larger veinlets, and even as 'nuggets.' Orpiment, pyromorphite and mimetite also have been recorded from this locality.¹

According to the manager, there was a downward distribution of the ores. In the highest 120 feet gold in a quartz gangue alone was found; galena and blende then came in, and at a depth of 200 feet the gold either disappeared entirely or was found sporadically. Pyrites and mispickel occurred throughout the lode. The blende and lead-ore were thrown on the dumps.

The greater part of the gold is said to have occurred near the surface, in a natural trough filled with clay and partially decomposed rock lying above the Bridge Lode. Another lode, the Chidlow Lode, has also been rather extensively worked, with good results. This lode averages 20 feet in thickness and courses parallel with the Main Lode.

The Bridge Lode consists of a number of small lodes coursing parallel with and about 40 feet north of the Main Lode. The whole series known as the Bridge Lode dips in one and the same direction, and at much the same inclination.

The Main Lode was worked open-cast down to adit-level. The adit, which has been driven northward, cuts the Main Lode at 500 yards distance. A shaft was sunk for a depth of 300 feet below adit, but no gold was found. The lode has good walls.

According to a section belonging to the company, there are three levels: the highest at 82 feet, the middle at 442 feet, and the adit at 800 feet below the surface. The length of the adit is given as 3,700 feet; that of the middle level as 2,230 feet; and that of the top level as 960 feet.

Water-power was obtained from two waterfalls, known as Pistyll-y-Cain and Rhaiadr-Mawddach.

During the period 1864-1907, when the mine was worked as a gold-mine, it produced 36,116 ozs. of gold from 96,569 tons of stone.² There are said to be good reserves of lead and zinc ores on the dumps and in the mines.

CARNARVONSHIRE.

Lead and zinc ores are mined in both western and eastern Carnarvonshire. The former area will be described under the

¹ Andrew, A. R., 'The Geology of the Dolgelley Gold-belt, North Wales.' *Geol. Mag.*, 1910, p. 261. *Vide* p. 267.

² Andrew, *op. cit.*, p. 267.

title of the Llanllyfni District, the eastern as the Llanrwst District. Some mines in the extreme south-eastern part of the county are referred to under the heading of the Llanengan District.

LLANLLYFNI DISTRICT.

GENERAL DESCRIPTION.

The Llanllyfni District embraces the mines near Tal-y-sarn in the Nantlle Valley, about 4 miles east of Llanllyfni, the mines being situated on the lower slopes of the mountains on both sides of the main road.

The country-rock consists of slates of Ordovician age.

Some of the lodes course west and east, others north-west and south-east, the former underlying south and the latter generally in a north-eastward direction. The ores consist of mixed sulphides, and include galena, blende, chalcopyrite, and pyrites. The galena is somewhat argentiferous, the content of silver ranging from 2 to 8 ozs. per ton of galena. The principal gangue-mineral is quartz.

Transport down the mountain slopes to the mills on the main road is difficult, but there is a good road thence to the railway-stations at Pen-y-groes and Nantlle (L. & N.W.R.).

DETAILS OF MINES.

MOUNTAIN LODGE MINE, LLANLLYFNI.

(*Standing.*)

The Mining Corporation of Great Britain, Ltd.,
119, Finsbury Pavement, E.C. 2.

Levels situated on the lower slopes of Mynydd Tal-y-mignedd, 3 miles east-south-east of Tal-y-sarn. The nearest railway-station, Pen-y-groes, lies about 5 miles by road west of the mine, and between the road and the mine there is a mile of mountain track.

Maps.—New Series One-inch Ordnance, 119 (Snowdon); Old Series Geological, 75 N.E.; six-inch, Carnarvonshire 21 S.E.

The country-rock consists of Ordovician slates. There are two lodes, Nos. 1 and 2, each 6 feet wide. They course south-east and north-west and underlie south-west at about 60° from the horizontal. The ore consists of mixed chalcopyrite, galena, and blende, in a gangue of quartz. There is also a little 'peacock' copper.

Three adits have been driven into the mountain side. No. 1 extends for a distance of 199 feet in a south-east direction and for another 32 feet in a south-west direction. No. 2 level has been driven 177 feet south-eastward and then turns south west for 72 feet. No. 3 is a cross-cut 133 feet long.

The company supply the following results of assays of the mixed ore, made by their adviser, Dr. Garbe: zinc, 21·46 per cent.; lead, 12·70 per cent.; silver, 4·4 ozs. to the ton.

The ore shows the following percentages : copper, 1 ; lead, 6·16 ; zinc, 20·5 ; and silver, $2\frac{3}{4}$ ozs. per ton. Some 'stuff' from a winze gave the following figures : copper, 1·48 per cent. ; lead, 19·52 ; zinc, 19·48 ; and silver, 8 ozs. per ton.

BENALLT MINE, LLANDWROC.

(*Standing.*)

The Consolidated Zinc and Lead Mines, Ltd., Benallt,
North Wales.

Levels situated on the lower slopes of Craig-y-Bere, about $1\frac{3}{4}$ miles east of Nantlle. Pen-y-groes, the nearest railway-station, lies about 5 miles by road west of the mine, and there is a quarter of a mile of mountain track between the road and the mine.

Maps.—New Series One-inch Ordnance, 119 (Snowdon) ; Old Series Geological, 75 N.E. ; six-inch, Carnarvonshire 21 N.E.

The country-rock consists of slate of Ordovician age. There are two lodes, which both course east and west, and underlie north at about 40° from the horizontal. They carry blende, and some galena with silver up to 40 ozs. to the ton, in a quartzose gangue.

The mine was worked by five levels driven into the mountain side. No. 5 is the lowest ; No. 4 is 135 feet above it, No. 3 is $21\frac{1}{2}$ feet above No. 4, and No. 2 is 70 feet above No. 3, and $73\frac{1}{2}$ feet below No. 1.

LLANENGAN DISTRICT.

LLANENCAN MINES.

(*Disused.*)

On the St. Tudwals peninsula, which forms the south-eastern corner of Carnarvonshire, lead and zinc ores were formerly raised at a series of seven mines ranged along a fault-vein that crosses the peninsula¹ from near Llanengan Church east-south-eastward to Porth-bâch, a distance of two miles.

On the original One-inch Ordnance Map, dated 1840, three shafts, marked 'Lead Mine,' are indicated at what appears to be the West Assheton and Assheton Mines, and a fourth is shown at or near the Penrhyn Mine. On the Geological Map, issued in 1851, the eastern part of the fault is shown as a mineral vein, and marked with the symbol for lead.

According to Mr. T. C. Nicholas,² writing in 1915, the lode was then nowhere visible, and the mines had all been abandoned for over twenty years. The lode traverses grits, sandstones and mudstones of Ordovician (Arenig) age.

¹ Maps : New Series One-inch Ordnance, 134 (Pwllheli) ; Old Series Geological, 75 S.W. ; six-inch, Carnarvonshire 45 S.W.

² 'The Geology of the St. Tudwal's Peninsula (Carnarvonshire).—*Quart. Journ. Geol. Soc.*, vol. lxxi, 1915, p. 83 ; *vide* p. 129.

In order from west to east the mines were named: Porth-Neigwl (Port-Nigel), Pant-gwyn, Tan-y-bwlch, Bwlch-y-toeyn, West Assheton, Assheton, and Penrhyn. The dumps, which have recently been examined by Mr. H. G. Dines, show plentiful specimens of galena and copper pyrites, with blende and barytes.

A plan of the Port-Nigel and Assheton Mines was deposited at the Home Office in 1883. The Mineral Statistics give the outputs shown in the Table below:—

Outputs of the Llanrwst Mines.

| Mine. | Years. | Lead Ore. | Lead obtained. | Silver obtained. | Zinc Ore. | Zinc obtained. |
|--|---------|-----------|----------------|------------------|-----------|----------------|
| | | Tons. | Tons. | Ozs. | Tons. | Tons. |
| Port-Nigel - - - | 1874-83 | 879 | 644 | 3,315 | | |
| Pant-gwyn - - - | 1882-87 | 2,333 | 1,494 | 8,689 | | |
| Tan-y-bwlch - - | 1873-86 | 8,722 | 5,213 | 29,939 | 447 | 55½ |
| West Assheton - - | 1876-81 | 1,895 | 1,467 | 5,818 | 864 | 80 |
| Assheton - - - | 1870-89 | 3,120 | 2,375 | 9,929 | 1,020 | 134 |
| Penrhyn - - - | 1871 | 25 | 19 | 135 | | |
| Pant-gwyn, Tan-y-bwlch, and Bwlch-y-toeyn. | 1888-92 | 2,991 | 2,368 | 10,770 | 255 | 100 |

LLANRWST DISTRICT.

GENERAL DESCRIPTION.

John Williams, in his book on this district,¹ recorded that “Lead mines abound in this place and have been dug for ages, as there have been many reliques found which proved that the Romans explored the bowels of this Nant: Sir John Wynne also mentions them in his letter to Sir Hugh Myddleton, September 1st 1625:—‘My skill is little, and my experience none at all in such matters; yet I ever had a desire to further my country in such actions as might be for their profit, and leave a remembrance of my endeavours. . . . I have leade ore on my ground in great store, and other minerals near my house, yf it please you to come hither’”.

Williams observed that the Alpine cress (*Thalyspi alpestris*) grows abundantly near the waterfall in the Pare Valley, on waste places and old walls, especially near the lead mines. His observation has since been verified and found to apply in other parts of the world, where certain species of plants have been observed to select rocks containing lead, zinc, or silver. At the Aix-la-Chapelle calamine mines, *Viola calaminaria* is regarded as an indication of productive ground for zinc ores; in Michigan, Wisconsin and Illinois, *Amarpha caulescens* is a sign of lead ore.

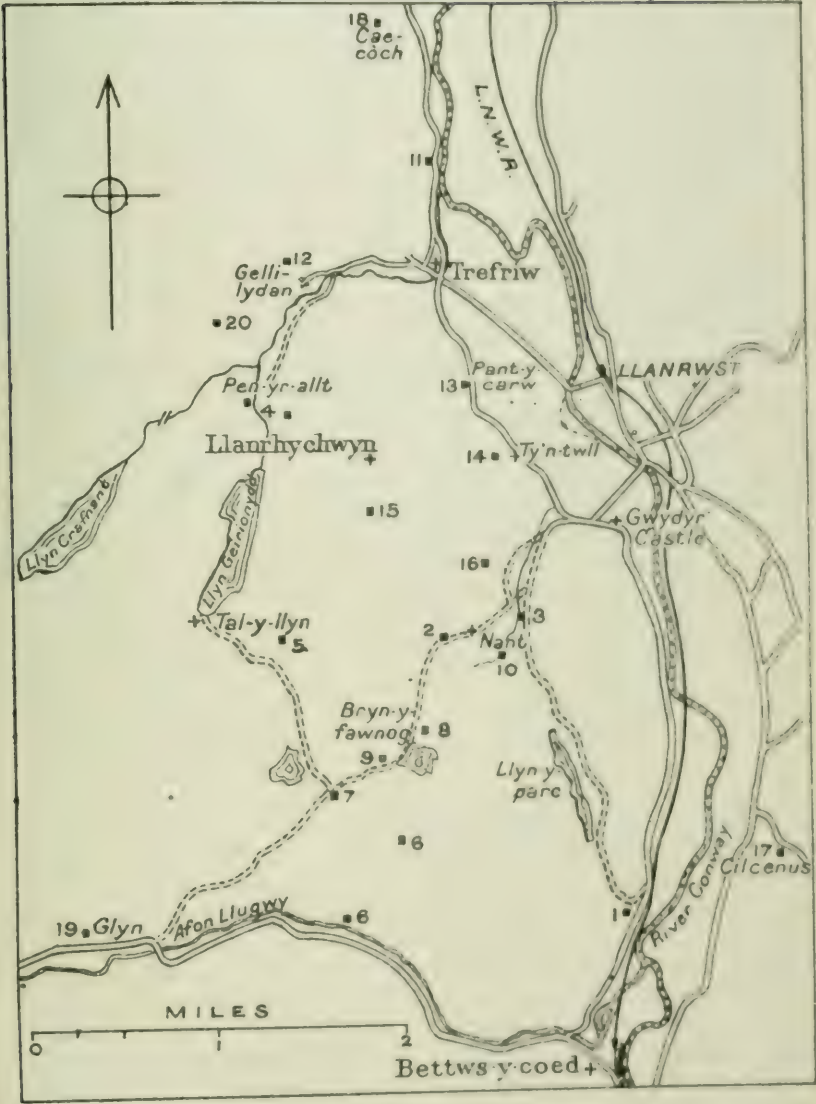
¹ ‘Faunula Crustensis, being an outline of the Natural Contents of the Parish of Llanrwst,’ *Llanrwst*, 1830, p. 22.

while in Montana, *Eriogonum ovalifolium* denotes the presence of silver-ore.

The Llanrwst District, which forms the principal lead and zinc region of the mountainous tract of North Wales, extends northward from the valley of the Llugwy near Bettws-y-coed for a distance of four miles to Trefriw (Fig. 12, p. 60). It is bounded on the east and west respectively by the Conwy Valley and the ridge of serrated hills about $3\frac{1}{2}$ miles to the west. One small mine has been worked on the eastern side of the Conwy valley, at Cilcenus, in Denbighshire, but this mine presents all the characteristics of the mines of this region. The principal producing mine is Trecastell, near Llangelynin, 8 miles north of Llanrwst, but both geologically and mineralogically this also belongs to this region. All the lodes lie in rocks of supposed Bala age. These consist of both sediments and volcanic ashes and lavas, and the lodes normally occupy fissures and crush-zones at the junction of the sedimentary with the igneous rocks. The district, which forms part of a compound syncline, with the principal axis striking north-east and south-west, is much dissected by faults. These faults are not clean-cut fissures, but crush-zones or shatter-belts, in which the rock is often completely comminuted. But it is only the slates and mudstones that become brecciated; the ashes resist the shearing movements, and merely split up into platy masses.

There are two series of lodes. One set runs north and south, *i.e.*, nearly parallel with the strike; the other runs east and west, in the direction of dip. Both sets appear to have been formed almost contemporaneously. Those coursing north and south are, however, a little later than the others, and displace them a few feet. The dip of the north-and-south series is as often to the west as to the east; that of the east-and-west lodes is in some cases north, in other cases south.

None of the lodes ranging north and south has clean-cut walls: all merge insensibly into the country-rock on one or both sides. They vary in thickness up to 80 feet, though this mineralized belt cannot correctly be designated a lode. The east-and-west lodes, on the contrary, seldom attain a greater width than 6 feet, and have better-defined walls. In all cases the workable material consists of a shatter-belt thoroughly cemented with gangue and other minerals. Most of the ore lies in the slaty breccia, and is cemented with quartz and calcite. Evidences of more than one period of movement are clearly seen in many of the lodes. After the crush-zone had been formed it was cemented with mineral matter; movements were then resumed, resulting in further brecciation, which was followed by a second period of mineralization. The cementing minerals are not similar in all the lodes. At the Hafna Mine, the first-formed breccia was cemented with quartz and zinc blende; this cement was then itself brecciated and further cemented with calcite. At the Cae-côch Mine (Fig. 12, No. 18), the breccia was cemented with pyrites, re-broken, and re-cemented with pyrites, calcite, and



SKETCH MAP OF LLANRWST DISTRICT.

quartz. At Cyffty Mine, the Cyffty Lode, consisting of a slate breccia, is cemented with galena, subsequently re-brecciated and then re-cemented with galena. At Pen-yr-allt Mine, large cubes of galena have been cracked, and re-cemented with fine-grained galena.

Galena and blende are the principal ores. They are frequently associated, and even intergrown, especially in the east and west lodes. The north-and-south lodes contain blende, often exclusively; but where the two minerals occur, as at Trecastell, galena covers the walls and encloses a central core of blende. Blende would therefore appear to be of somewhat later date of formation than galena, but the difference was probably not great. There are signs of a geographical zonal arrangement of the ores, which may be due to the synclinal structure of the field. On approaching the syncline from the east, zinc blende is first met with, galena being subordinate, as at the Gileenus, Aberllyn and Parc Mines; nearer the centre of the syncline, galena forms the predominant constituent of the lodes, while in the higher beds pyrites becomes the principal ore, as at Ty-hwnt-y-gors (Llanrhychwyn) and Cae-côch, Trefriw.

The gangues vary according to the petrographical character of the country-rock. In the volcanic rock, quartz forms the principal constituent, whereas in the slate country calcite is predominant. In the Trecastell Mine there is a remarkable instance of the effect of the country-rock upon the constitution of the lode. A bed of black chert is cut across by the lode between the 65- and the 85 fathom levels; where the lode cuts the chert both blende and galena entirely disappear, leaving only the gangue-minerals. The lode on both sides of the chert is about equally rich in lead and zinc ores. No similar case has been observed in this district; but the deterioration or even sterility of lead-lodes in arenaceous sediments is a well-ascertained fact in Cornwall.¹

The principal gangue-mineral of most of the lodes is calcite, which assumes a variety of forms, many being beautiful on account both of their shape and their colour. Schiefer-spar (a form of calcite) has been found in some abundance at the Parc and Hafna Mines, but not elsewhere; while many fine specimens of the 'leaf spar' or 'rose spar' of the local miner can be obtained on the dumps. Quartz usually assumes the saccharoidal habit, but at the Llanrwst and Bryn-eisteddfod Mines it consists of a mass of pyramidal crystals. Several of these crystals measured half an inch along the principal axis and resembled 'Buxton diamonds,' while on many of them a short length of the prism has been preserved. This mass is intergrown with minute cubes and octahedra of galena and, rarely, with crystals of blende. In parts of the lode this quartzose material has been brecciated and re-cemented with galena and galena.

¹ See 'Special Reports on the Mineral Resources of Great Britain,' vol. xxi, Lead, Silver-lead and Zinc Ores of Cornwall, Devon and Somerset (*Mem. Geol. Surv.*, 1921, p. 1).

Cerussite is not common, but beautiful incrustations are found on the roofs and walls of some of the levels at the Cyffty Mine. They are tender and difficult to obtain in perfect condition, but many of the crystals measure an inch in length. In the old zinc-mines hydrozincite ($\text{ZnCO}_3 \cdot 2\text{Zn(OH)}_2$, a mixed carbonate and hydrate) forms a characteristic white covering on the walls, and hangs from the roof and grows up from the floor in stalactitic and stalagmitic masses. It is often stained by the varied tints of hydrated oxides of iron. Cockscorn pyrites is rare, but occurs at Cyffty and also at the Hafna Mine.

In view of the abundance of barytes in many lead-districts it is remarkable that none has been found in the Carnarvonshire mines. An analysis of several hundred tons of ore at Trefriw showed an average of only 0.11 per cent. of barium sulphate.

Over the whole district the ratio of ore to gangue averages from 8 to 15 per cent. of galena and 8 to 10 per cent. of blende. The proportion of galena to blende varies in different lodes. At the Parc Mine the ratio is as 2 to 1, while at Tre Castell Mine there is 60 per cent. of blende to 40 per cent. of galena. The percentage of the metals in the minerals does not vary greatly; that of lead in the galena ranges from 78 to 84, that of zinc in the blende ranges from 36 to 53 per cent. The lead-ores are not richly argentiferous. At several mines the average has been found to be 2 ozs. of silver per ton of galena; at Tre Castell, however, the galena has contained up to 18 ozs. of silver per ton; and at Parc Mine, 10 ozs. per ton.

DETAILS OF MINES.

ABERLlyn MINE, BETTWS-Y-COED.

The Aberllyn Mines, Ltd., Bettws-y-coed.

Shafts and levels situated 7 furlongs north of Bettws-y-coed Church and Station (L. & N.W.R.). Fig. 12, No. 1.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 S.W.

The country-rock consists of black slates and felspathic ash of Ordovician age.

Two lodes are worked, known as the Hard Lode and the Shale Lode. These unite at the mouth of the levels at a point about 100 yards north of the mills.

The Hard Lode lies to the west, courses true magnetic north and south (1919), and underlies to the east at 18° from the vertical. Though there is no true hanging-wall, there is a good footwall. In the workable parts the lode averages 20 feet in width. It has a hard quartzose gangue, cementing brecciated black slate and some ash, and contains thin veins of blende as well as vugs lined with crystals of blende. The ore is of lower grade than that of the Shale Lode. In some parts of its course this type of lode suffered a second period of brecciation, after which it was re-cemented with iron pyrites. This secondary mineralization is

well seen in Level No. 4, in the western section of the mine, where large masses of pyrites occur, and on decomposition give rise to ochreous mud. Northwards, at the northern end of Llyn-y-pare, the lode has been proved by a cross-cut to be continuous with the Gors Lode of the Pare Mine (p. 65).

The Shale Lode also courses magnetic north and south, underlies east at 18° from the vertical, and averages 20 feet in width; but the workable ore assumes the form of bunches. Examination of the underground workings shows that these bunches are all shear-lenticles or augen of blende in slickensided black carbonaceous shale; there is hardly any quartz present. The working-faces afford evidence that the ore was formerly a vein or continuous band that has subsequently been broken up into lenticular bunches. This lode is continuous with the Shale Lode of the Pare Mine (p. 65).

The country-rock lying between the Hard Lode and the Shale Lode consists throughout of a brecciated mass cemented with quartz, and carries small values of zinc blende. In places an intermediate lode, or rather an enriched zone in the country-rock, has been worked. It appears, therefore, that the two lodes constitute a wide band of mineralized fault-rock. From field-evidence this fault appears to be an 'overthrust,' along which the Bala slates have been thrust from the east over the felspathic ash, the movement being accompanied by shattering of the rock over a wide belt. After this movement, mineralization took place, followed by a recurrence of movement and a second period of mineralization.

In the western section of the mine, where the Hard Lode is worked, there are six levels. No. 4 Level has been driven northward at a depth of 75 feet beneath the waters of Llyn-y-pare. On the Shale Lode also there are six levels.

Power is obtained by conveying water from Llyn-y-pare through 12-inch pipes to operate two 200 H.P. Pelton turbines. After being used in the mills the water is carried through a mile of leat so as completely to precipitate the sediment before the water is allowed to pass into the river Conwy.

Oil-flotation processes are employed to separate the ore from the gangue. Formerly, when water-separation only was used, the concentrate was never more than 60 per cent. Too fine grinding led to greater loss on account of the fine ore floating, whereas too coarse grinding gave too low a proportion of zinc in the concentrate and an excess of gangue-stuff.

The ore has never given a higher proportion of zinc in the assays than 43 per cent., and the lode-stuff a higher percentage than 8 of zinc.

The old workings of this mine are remarkable for the coatings of hydrozincite on the walls. The Great or Cathedral Stope is entirely covered with this substance, and long stalactites hang from the roof. These are soft, and consist of colloidal hydrozincite; on exposure to air they rapidly harden, and form a

cement wherever they fall on the debris of the floor. In workings abandoned only twenty years ago this substance forms a layer nearly a quarter of an inch thick.

From 1899 to 1904 there was an output of 25 tons of lead-ore, which contained from 78 to 80 per cent. of lead. At various periods between 1869 and 1904 some 2,548 tons of zinc-ore were raised. It contained from 29 to 44 per cent. of zinc.

PEN-YR-ALLT MINE, BETTWS-Y-COED.

(*Standing.*)

The Aberllyn Mines, Ltd., Bettws-y-coed.

Levels situated 7 furlongs north of Bettws-y-coed Church and Station (L. & N.W.R.). Fig. 12, No. 1.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 S.W.

The country-rock consists of black shales and felspathic ash of Bala age.

The lode, which is known as the Pen-yr-allt Lode, courses east and west, underlies north at about 1 in 3, and averages 4 feet in width. The gangue consists of comminuted country-rock cemented with quartz; the ores are galena and zinc blende in equal parts.

The lode has been extensively worked along five levels up the mountain side, the lowest level being near the railway-track.

HAFNA MINE, LLANRWST.

(*Standing.*)

Shafts and levels situated on the west side of the Nant-Gwydyr valley and about $1\frac{1}{2}$ miles by road south-west from Llanrwst. Fig. 12, No. 2.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 N.W., 18 N.E.

Shales and felspathic ash of Bala age, with an intrusive sill of greenstone, compose the country-rock.

There are two lodes, one coursing west-north-west, the other north and south. The west-north-west lode, which is the main lode, is nearly vertical, with a slight underlie to north-north-east. Where it outcrops on the top of a neighbouring pass it was worked open-cast.

The lode consists of a gangue of brecciated country-rock cemented with quartz. In places the lode has been re-brecciated, and re-cemented with calcite, the dominant characteristic of the vein-stuff. The brecciated constituents include blende of an earlier period of mineralization, as well as slate and quartz. The principal ore, however, is galena; locally pyrites also forms an important constituent.

Some beautiful examples of schiefer-spar have been found, and specimens may still be got from the dumps. Cockscorn pyrites is also abundant, and has not been found elsewhere in the district except at the Cyffty Mine. Some of the lead ore contained 7 ozs. of silver per ton; the average was only 4 ozs.

The mine was worked by five levels, driven into the precipitous sides of the Nant valley; there are also shafts for winding and ventilation. The output of the mine is shown by the following Table, taken from the official Mineral Statistics.

Output of the Hafren Mine.

| Year. | Lead Ore. | Percent of Lead in Ore. | Lead obtained by Smelting. | Zinc Ore. | Percent. of Zinc in Ore. |
|----------|-----------|-------------------------------|-------------------------------------|-----------|--------------------------------|
| | Tons. | | Tons. | Tons. | |
| 1860 - - | 4 | — | 2 | — | — |
| 1864 - - | 11 | — | 8 | — | — |
| 1865 - - | 7 | — | 5 | — | — |
| 1866 - - | 12 | — | 9 | — | — |
| 1867 - - | 6 | — | 4 | — | — |
| 1868 - - | 2 | — | 1 | — | — |
| 1869 - - | 2 | — | 1 | — | — |
| 1872 - - | 1 | — | 1 | — | — |
| 1873 - - | 3 | — | 2 | 2 | — |
| 1874 - - | 2 | — | — | — | — |
| 1875 - - | 2 | — | 2 | — | — |
| 1880 - - | 11 | — | 10 | — | — |
| 1881 - - | 36 | — | — | — | — |
| 1882 - - | 2 | — | — | — | — |
| 1890 - - | 7 | 83 | — | — | — |
| 1891 - - | 17 | 82 | — | — | — |
| 1892 - - | — | — | — | — | — |
| 1893 - - | 20 | — | — | 60 | 35 |
| 1894 - - | — | — | — | — | — |
| 1895 - - | 5 | 80 | 4 | 32 | 33 |
| 1898 - - | 27 | 81 | — | 229 | 42 |
| 1899 - - | 100 | 80 | — | 583 | 45 |
| 1900 - - | 67 | 80 | — | 414 | 42 |
| 1907 - - | 19 | 81½ | — | 126 | 43 |
| 1908 - - | 83 | 82½ | — | 442 | 42 |
| 1909 - - | 112 | 82 | — | 208 | 41 |
| 1910 - - | — | — | — | — | — |
| 1911 - - | 50 | 82 | — | 70 | 44 |
| 1912 - - | 122 | 82 | — | — | — |
| 1913 - - | 74 | 80 | 56 | 389 | 40 |

PARC MINE, LLANRWST.

The Llanrwst Consolidated Mines, Ltd., Park Mine, Llanrwst.

Shafts and levels in Nant-Gwydyr, about a mile south-west of Llanrwst. Fig. 12, No. 3.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 N.W.

The country-rock consists of sediments and felspathic ashes of Bala age.

The Shale Lode, the most easterly lode of the district, courses north and south, underlies east at 20° from the vertical, and ranges from 40 to 80 feet in width. It is not a clean-cut fissure, but a belt of brecciated rock, cemented and mineralized; and there are indications of two periods of both movement and mineralization. The gangue is chiefly comminuted black shale, with occasional patches of calcite and of quartz, and with 'bunches' of zinc blende here and there. These 'bunches' are in reality 'shear-lenticles,' and represent the torn-out fragments of a once continuous lode. This mineralized belt, the Shale Lode, has been followed from near Ty-mawr (Ty'r-mawn), west of Llanrwst, for a distance of nearly three miles southward, through the Park Mine to the northern end of Llyn-y-parc. It reappears at the southern end of that lake, where it is worked at the Aberllyn Mine, and still retains the character of a string of shear-lenticles of zinc blende in brecciated country-rock.

Coursing parallel with this lode is the Gors Lode. It underlies east at 20° , and varies in width from 12 to 30 feet. The gangue consists of saccharoidal quartz enclosing galena and blende, both separately and also as intergrowths. This lode also has been traced in a southerly direction to the Aberllyn Mine, where, however, it contains blende almost to the exclusion of galena. At Parc it is worked at the Gors Shaft. A 'pipe' of galena was worked, which yielded 16,000 tons of concentrate.

The Fuches-lâs Lode also courses north and south, but underlies west. In the upper workings it averages only 2 feet in width, whereas in depth it widens to as much as 5 feet. Both galena and blende have been found in it, the latter, however, in only subordinate quantities.

There is also a number of lodes that course from west to east. One of these is called at Parc the Principal Lode. It underlies to the north at 1 in 3 and in width varies from 2 feet near the surface to as much as 12 feet at depth. Its gangue consists of quartz and slate fragments, in which galena and blende occur in the ratio of 1 ton of galena to half a ton of blende. The country-rock is hard indurated slate.

A ton of ore yields $8\frac{1}{2}$ per cent. of galena and $4\frac{1}{4}$ per cent. of blende. The reserves in sight are estimated at 57,000 tons of ore of 10 per cent. quality. The ore assays 2 ozs. of silver to the ton. At a distance of 200 yards inward from the adit-mouth this lode has been shifted northward for a distance of several feet by the Fuches-lâs Lode.

The Principal Lode is being worked at the new adit near the intersection of the Fuches-lâs Lode at a distance of 600 feet from the entrance. The ore there consists of galena with some blende in a matrix of calcite and saccharoidal quartz, with

occasional stringers of pyrites and more rarely of copper pyrites. The crystals of calcite vary in size from mere grains up to forms measuring an inch across. Star-calcite and schiefer-spar occur rarely. Some of the lode consists of brecciated black mudstone cemented with quartz and often with blende and calcite.

The adit-level is at present (1919) about 1,850 feet long; there are six other levels on the different lodes, and a shaft, 80 fathoms in depth, on the Gors Lode, from which three levels have been driven along the lode.

The footwalls of these lodes are said to be well defined, whereas the hanging-walls are vague and consist of mineralized layers of sheared country-rock. In part of its course the Shale Lode is an overthrust.

The output of the mine as given in the official 'Mineral Statistics' is shown in the Table below:—

Output of the Parc Mine.

| Year. | Lead Ore. | Percent. of Lead in Ore. | Lead obtained by Smelting. | Zinc Ore. | Percent. of Zinc in Ore. |
|----------|---------------|--------------------------------|-------------------------------------|-----------|--------------------------------|
| | Tons. | | Tons. | Tons. | |
| 1860 - - | 49 | — | 36 | — | — |
| 1864 - - | 20 | — | 15 | — | — |
| 1865 - - | 16 | — | 12 | — | — |
| 1866 - - | 5 | — | 4 | — | — |
| 1872 - - | 60 | — | 46 | — | — |
| 1873 - - | 45 | — | 35 | — | — |
| 1874 - - | 12 | — | 8 | — | — |
| 1875 - - | $\frac{1}{2}$ | — | — | — | — |
| 1894 - - | 4 | 82 | 3 | 25 | 47 |
| 1895 - - | 37 | 78 | 28 | 215 | 46 |
| 1896 - - | 40 | 80 | 30 | 250 | 40 |
| 1899 - - | 19 | 80 | — | 168 | 45 |
| 1900 - - | 66 | 81 | — | 174 | 44 |
| 1908 - - | 90 | 81 | — | — | — |
| 1909 - - | 61 | 81 | — | — | — |
| 1910 - - | 128 | 81 | — | — | — |
| 1911 - - | 182 | 81 | — | — | — |
| 1912 - - | 33 | 75 | — | — | — |
| 1913 - - | 273 | 80 | 207 | 152 | 32 |

In addition the Fuchel-lâc Level produced 35 tons of lead ore between 1860 and 1873. Some of the lead contained 6 to 7 ozs. of silver per ton.

KLEDDYCE MINE, LLANRWST.

The Crafnant and Devon Mining Syndicate, Ltd.,
175, Piccadilly, W. 1.

Levels and openworks between Llyn Geirionydd and Pen-yr-allt, about 2 miles west of Llanrwst. Fig. 12, No. 4.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six inch, Carnarvonshire 18 N.E.

The country-rock consists of felspathic ash and slate of Bala age, with some intrusive sills of greenstone. The beds dip in a general easterly direction.

There are many small lodes in the sett, all carrying galena with a little blende and much iron pyrites. They are all of the nature of crush-belts, with the brecciated country-rock strongly cemented with quartz; but not much calcite has been observed. In this respect they differ from most of the other lodes of the Llanrwst district. Some course about north and south, others nearly east and west.

The principal lode lies in the valley below the 'step' up to Llyn-Geirionydd. It courses east and west, underlies northward at 20° from the horizontal, and ranges from 9 inches to 1 foot in width. Its hanging-wall is good, but there is no real footwall, as the country-rock merges into the lode and consists of greatly comminuted black shales.

Ash ('grey rock') forms part of the western wall of the principal north-and-south lodes.

Another lode courses north and south and appears in the main level near the mills. It dips east at about 45° and carries galena.

Many other small lodes and cross-courses have been exploited in the gorge and also in the tributary valleys on its eastern side; all carry some galena and blende and rather large quantities of iron pyrites.

Hitherto, galena samples are said to have shown on dry assay 82 per cent. of lead and about 32 ozs. of silver to the ton. The blende contains about 42 per cent. of zinc. The extraction varies from 27 to 32 per cent. of ore from the gangue-material. The mine is worked by a main level, which enters the hill opposite the mills and after running a few yards eastward turns southward. It is proposed to drive this level to meet the principal lode and to make it the main haulage-way.

At present the ore is carried by aerial ropeway from the mine to the mills, is then dropped through hoppers into a jaw-crusher, over coarse and fine grizzlyls to other crushers, and thence to trommels, jigs and Sturtevant tables. The fines are treated on vanners. Power is obtained from an 82 H.P. turbine, driven by water conveyed from Llyn-Geirionydd. The quantity of ore put through the mill averages about 4 tons per 8 hours, or 25 tons per week.

The company may take up five other propositions, namely Caerhegla (Fig. 12, No. 20), Ffrith-Sian, Ty-hwnt-y-gors, Tan-yr-eglwys and Pen-yr-allt.

NEW PANDORA MINE, LLANRWST.

The Western Development Co., Ltd., 23, Queen Victoria Street, E.C. 4

Shafts situated half a mile east of Tal-y-llyn, $2\frac{1}{2}$ miles south-west of Llanrwst. Fig. 12, No. 5. This mine has been called the Willoughby-Foxdale Mine and Welsh Foxdale.

Maps.—New Series. One-inch Ordnance, 196. Old Series Geological, 78 S.E.: six-inch, Carmarvonshire 18 N.E.

The country-rock is principally slate of Bala age, the dip of the beds being northward. Felspathic ashes, however, occur over the southern part of the sett, and are traversed by a series of small lodes or cross courses.

There are three principal lodes, called respectively the New or East-and-West Lode, the Goddard, Main, or North-and-South Lode, and the Champion Lodes.

The Goddard Lode courses nearly north and south, underlies east at 70° from the vertical, and varies in width from 4 feet to 30 feet, with an average of 5 feet. It has good walls. The ore is mainly blende; but some rich bunches of galena associated with iron pyrites have been found in ground below the 23 fathom level. The gangue is mainly calcite.

The New or East and West Lode courses north north east and south-south-west, underlies west north west at 60° , and varies in width from 8 feet to 14 feet, with an average stopping width of 10 feet. It carries galena as the principal ore, but locally there are remunerative quantities of blende. At the end of the 33-fathom level some iron pyrites has been found. The gangue is chiefly calcite, with some brecciated country rock.

The Champion series of lodes courses north north east and south-south-west and underlies nearly west, but the lodes are practically vertical. The thickness is variable, and seldom exceeds 8 feet. There are many 'horses' in the lodes, and the best values are got from near the walls.

In the 23-fathom level south, at a junction of the Goddard Lode with four lodes of the Champion series, the Goddard Lode is considerably enriched and enlarged; but generally these cross-courses are poor in lead and blende, and rather pyritic. A lode lying to the south of this series has recently been prospected on its outcrop. It consists to a large extent of pyrites and calcite with some blende, and courses nearly due east and west. Its country-rock consists of felspathic ash of Bala age.

The ore from all these lodes exhibits the mode of formation characteristic of this lead and zinc area. It consists of a breccia of slate or ash fragments, cemented with calcite and galena with blende, and no difference has been observed between the mineral contents of the north-and-south lodes and those of lodes coursing in other directions.

The proportion of lead in the galena averages about 80 per cent; that of zinc in the blende about 44 per cent. Some silver also is obtained on smelting the lead.

There are five levels on the New Lode, all worked from the main shaft. These are at about 10 fathoms intervals and are known respectively as the 13-, 23-, 33-, 45-, and 55-fathom levels. The drainage-level, or adit, which has been driven from the mountain side above Llyn-Geirionydd for a distance of 1,450 feet, intersects the main shaft at the 33-fathom level.

This level has been driven for a distance of 1,186 feet west of the shaft.

On the Goddard Lode there are three levels, at 13, 23, and 33 fathoms respectively below adit-level, but there has not been much stoping done below the 23-fathom level. Good values of galena, however, are said to occur below that level.

The power used is producer-gas. The plant consists of a crusher with rolls, trommels, jigs and Wilfley tables, and a compressor. The mills formerly employed were those situated in the valley below Llyn-Geirionydd, but these are now being used by the Klondyke Mine.

Hitherto the mine has produced more zinc-ore than galena, but during 1919 there was rather more galena than blende.

The output is given in the Table below. The neighbouring D'Eresby Level had an output of lead-ore amounting to 1,393 tons, which were raised between 1879 and 1891. It was re-worked in 1901, when 52 tons were recorded.

Output of the New Pandora Mine.

| Year. | Lead Ore. | Percent. of Lead in Ore. | Lead obtained by Smelting. | Zinc Ore. | Percent. of Zinc in Ore. |
|----------|-----------|--------------------------------|-------------------------------------|-----------|--------------------------------|
| | Tons. | | Tons. | Tons. | |
| 1877 - - | 142 | — | 116 | 195 | — |
| 1878 - - | 132 | — | 106 | 230 | — |
| 1879 - - | 292 | — | 235 | 203 | — |
| 1880 - - | 242 | — | 200 | 231 | — |
| 1881 - - | 272 | — | — | — | — |
| 1882 - - | 198 | — | — | — | — |
| 1894 - - | — | — | — | 138 | 48 |
| 1895 - - | — | — | — | 243 | 48 |
| 1896 - - | — | — | — | 54 | 45½ |
| 1897 - - | 1 | 82 | — | 48 | 36 |
| 1909 - - | 8 | 79 | — | 79 | 37 |
| 1910 - - | 90 | 82 | — | 358 | 42 |
| 1911 - - | — | — | — | 60 | 37 |

POOL MINE, BETTWS-Y-COED.

(*Standing.*)

John Whieldon, 24, Abinger Road, W. 4.

Shafts and levels situated about 1¾ miles west-north-west of Bettws-y-coed. Fig. 12, No. 6. The mine has been known as the Cwm-mawr Mine.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 18 S.E.

The country-rock is chiefly shale of Bala age, but beds of felspathic ash occur in the adit-level.

There are, in all, eight lodes, of which only two were much worked. These lodes are called respectively the Challinor Lode and the Cyffty Lode. They both course east and west, underlie

south at one in three, and average $2\frac{1}{2}$ feet in width. In them galena occurs in bunches. Calcite and quartz are the principal minerals that compose the gangue. The other lodes also course from east to west and carry lead ore with a little blende. Some masses of galena, weighing three quarters of a ton each, were found in the Cyffty Lode.

The mine was worked by a series of levels. The adit level, which opens on the north side of the River Llugwy at a point about half a mile east of the Swallow Falls, is 1,400 yards in length and intersects several lodes. The principal shaft is 20 yards deep; its bottom is 300 feet above the adit level. From this shaft a number of levels were driven along the lodes.

The power used at the mills is obtained from water carried across the river in twelve inch pipes to a Pelton (turbine) wheel. There is a stone breaker, a pair of rollers, two pigs, a Record vanner, and elevators.

The mine has been largely worked down to 20 fathoms. Lead-ores have also been raised at Glyn, $1\frac{1}{2}$ miles farther west, near the Capel-Curig road (Fig. 12, No. 19). The output of Pool is shown in the Table below.

Output of the Pool Mine.

| Year. | Lead Ore. | Percent. of Lead in Ore. | Lead obtained by Smelting. | Silver obtained by Smelting. |
|-------|-----------|--------------------------------|----------------------------------|------------------------------------|
| | Tons. | | Tons. | Ozs. |
| 1855 | 20 | — | 13 | — |
| 1856 | 112 | — | 73 | — |
| 1857 | 146 | — | 94 | — |
| 1858 | 161 | — | 104 | — |
| 1859 | 34 | — | 26 | — |
| 1860 | 63 | — | 47 | — |
| 1861 | 71 | — | 49 | 476 |
| 1862 | 107 | — | 77 | 770 |
| 1863 | 93 | — | 70 | 700 |
| 1864 | 40 | — | 30 | 300 |
| 1865 | 36 | — | 27 | 270 |
| 1866 | 42 | — | 31 | 94 |
| 1867 | 35 | — | 24 | 30 |
| 1868 | 11 | — | 9 | — |
| 1869 | 2 | — | 1 | — |
| 1874 | 14 | — | 10 | — |
| 1875 | 11 | — | 8 | — |
| 1876 | 10 | — | 7 | — |
| 1877 | 38 | — | 32 | — |
| 1878 | 40 | — | 32 | — |
| 1879 | 10 | — | 33 | — |
| 1880 | 15 | — | 12 | 60 |
| 1906 | 40 | 81 | — | — |
| 1907 | — | — | — | — |
| 1908 | 12 | 80 | — | — |
| 1909 | 90 | 82 $\frac{1}{2}$ | — | — |
| 1910 | 160 | 84 | — | — |
| 1911 | 20 | 85 | — | — |

CYFFTY MINE, LLANRWST.

Great Challinor Mines, Ltd., 6, South Street, Finsbury, E.C.2.

Shafts situated 2 miles north-west of Bettws-y-coed and $2\frac{1}{2}$ miles south-west of Llanrwst. Fig. 12, No. 7.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 18 S.E.

The country-rock consists of slates and felspathic ashes of Bala age.

There are two main lodes, called respectively the Principal Lode and the Cyffty Lode.

The Principal Lode, which courses approximately north-east and south-west, is nearly vertical on the western side of the sett, underlies northward at 3° in the middle ground, and flattens towards the east. It varies in width from 3 feet to 9 feet and averages $4\frac{1}{2}$ feet. It is said to run without interruption through the Gorlan and Llanrwst Mines to the Parc Mine.

From south-west to north-east the lode crosses the junction of the ashes and slates, and the character of the gangue changes with the different kinds of country-rock. While in the ashes it consists mainly of quartz without any brecciated rock, whereas in the slate it is mostly brecciated country-rock cemented with calcite, quartz being only subsidiary. The lode everywhere has a good hanging-wall, but the footwall is always ill defined. The mineral association is complex, the lode containing, in addition to galena, small quantities of cerussite, pyrites, chalcopryite, and blende. Some of the galena has crystallized out in the form of octahedra in drusy cavities; but more characteristic is its massive form, blocks measuring a cubic foot of solid galena being common at the 200-foot level.

The percentage of metallic lead in the lode at present worked has not been determined; but formerly it ranged up to 15 per cent. The concentrates run up to as much as 80 per cent. of galena. Some of the ore shows negative crystals where rhombs of calcite have been dissolved out; many of the cavities are lined with a hair-like growth of cerussite.

The Cyffty Lode, which courses north and south, underlies west, though nearly vertical. Its width averages 4 feet, but increases locally to 6 feet. It intersects the Principal Lode about midway between the two shafts. The characters of the lode and gangue are similar to those of the Principal Lode, but the Cyffty Lode contains more cerussite.

The back of the Principal Lode can still be seen in some old trial-pits on the south side of the adjacent road.

The evidences of two periods of movement and of mineralization are exceptionally well seen in this mine. The brecciated country-rock was cemented with galena, after which the galena was itself broken up into fragments and re-cemented with new galena. Calcite and quartz crystals show a similar history of formation, partial destruction, and re-formation.

There are two principal shafts, that at the eastern end of the sett, known as the Engine Shaft, being 200 feet deep; the Winding Shaft, at the western end, is about 170 feet deep. These are connected by the 200-foot level. Adit level at the Engine Shaft is at a depth of 100 feet. The principal level lies at about 14 yards below the deep adit, and there is a short intermediate level between this and the 200-foot level.

The plant consists of a Masson jaw crusher, rolls, trommels, jigs and buddles; the power is derived from steam, and water from Llyn-ty'n-y-mynydd operating a 35 foot water-wheel.

From 1886 to 1911 some 344 tons of lead ore were raised. The percentage of lead in the ore ranged from 80 to 82·5, the average being 81.

LLANRWST MINE, BETTWS-Y-COED.

(Idle.)

Shafts and levels situated on the northern side of Llyn-y-sarnau, 2 miles south west of Llanrwst. Fig. 12, No. 8.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 18 S.E.

The country-rock consists of sediments and felspathic ashes of Bala age.

There are two principal lodes coursing generally north and south, intersected by two others coursing about north-east and south-west.

Here a valley-step, some fifty feet in the rise, has been trenched by a river now flowing in a chasm. On the eastern side of this chasm a series of levels has been driven on the lodes, and several shafts have been sunk to the levels. On the north of Llyn-y-sarnau lie the principal shaft and the mine-houses. There are also extensive dumps, which contain considerable quantities of galena.

The gangue consists of a friable mass of white quartz-crystals, nearly all of which present crystalline shape, many being bipyramidally terminated. In some the two pyramids are separated by a narrow prism-zone; most are less than an eighth of an inch long. Exceptionally, crystals measuring half an inch along the principal axis may be found, loosely aggregated, among the smaller forms. These crystals resemble the 'Buxton diamonds' of Derbyshire,¹ and to some degree the quartz-rock in the Carboniferous Limestone of Derbyshire.² Throughout this mass galena in cubes of different sizes is distributed. Some of the galena-crystals are microscopic in size, while many others

¹ F. W. Rudler, 'Handbook to the Minerals of the British Islands,' (*Mem. Geol. Surv.*), 1905, p. 136.

² H. H. Arnold-Bemrose, *Quart. Journ. Geol. Soc.*, vol. liv, 1898, pp. 169–183.

form lumps several inches across. Blende is not a common constituent of this lode. Other parts of the gangue consist of saccharoidal quartz that has been brecciated and re-cemented with calcite and galena, indicating two periods of movement and of mineralization. The black slate-breccia characteristic of the Llanrwst mining-area is uncommon; but volcanic ash, without any sign of brecciation, is frequently veined with lead-ore. Octahedral forms of galena and many well-shaped rhombohedra of calcite form part of the lode, but schiefer-spar was not observed.

The Table below shows the output of lead-ores, with amount of metal obtained by the smelting of the lead :—

Output of the Llanrwst Mine.

| Year. | Lead Ore. | | | | Lead obtained by Smelting. | | | |
|-------|-----------|---|---|-----|----------------------------|---|---|-----|
| | Tons. | | | | Tons. | | | |
| 1848 | - | - | - | 21 | - | - | - | 14 |
| 1849 | - | - | - | 18 | - | - | - | 10 |
| 1852 | - | - | - | 115 | - | - | - | 88 |
| 1853 | - | - | - | 39 | - | - | - | 30 |
| 1854 | - | - | - | 38 | - | - | - | 28 |
| 1855 | - | - | - | 62 | - | - | - | 48 |
| 1856 | - | - | - | 80 | - | - | - | 61 |
| 1857 | - | - | - | 99 | - | - | - | 76 |
| 1859 | - | - | - | 49 | - | - | - | 38 |
| 1860 | - | - | - | 32 | - | - | - | 25 |
| 1862 | - | - | - | 30 | - | - | - | 23 |
| 1863 | - | - | - | 60 | - | - | - | 45 |
| 1864 | - | - | - | 30 | - | - | - | 20 |
| 1865 | - | - | - | 11 | - | - | - | 8 |
| 1869 | - | - | - | 6 | - | - | - | 5 |
| 1877 | - | - | - | 100 | - | - | - | 81 |
| 1878 | - | - | - | 350 | - | - | - | 275 |
| 1879 | - | - | - | 46 | - | - | - | 33 |
| 1880 | - | - | - | 283 | - | - | - | 220 |
| 1881 | - | - | - | 3 | - | - | - | — |
| 1906 | - | - | - | 28 | - | - | - | — |
| 1907 | - | - | - | 80 | - | - | - | — |

In 1906 the percentage of metallic lead in the ore was 82·5; in 1907 it was 80. In 1864 the amount of silver obtained from the 30 tons of lead-ore was 42 ozs.; in 1880 the amount obtained from the 283 tons of lead-ore was 450 ozs.

At the adjacent Alltwen Level about 120 tons of lead-ore were obtained between 1862 and 1878.

GORLAN MINE, LLANRWST.

(Idle.)

Levels and shafts situated about a quarter of a mile south-east of Bryn-y-fawnog, 2 miles south-west of Llanrwst. Fig. 12, No. 9.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 18 S.E.

The country-rock consists of felspathic ash of Bala age.

A small lode carrying galena has been exploited in a level driven in a westerly direction.

At various periods between 1862 and 1888 there were 735 tons of lead-ore produced. In 1882 621 tons of lead-ore yielded on smelting 2.233 ozs. of silver.

BRYN-ISTEDDUD MINE, LLANRWST.

(Idle.)

Levels situated near Nant, $1\frac{1}{4}$ miles south-west of Llanrwst. Fig. 12, No. 10.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carmarvonshire 19 N.W.

The country-rock consists of felspathic ashes and black shales of Bala age.

The principal lode courses north-east and south-west, and underlies north-west at about 60° from the horizontal. The lode consists of brecciated black slate cemented with calcite and quartz, in which galena occurs as large cubes and also in a granular state. There is evidence of two periods of movement and mineralization. Firstly, pyrites infilled a fissure in black slate; this became broken up, and afterwards re-cemented with quartz, calcite, and galena. Two faults at the junction of the ashes and the sediment throw out strong springs of water.

The mine was worked by day-levels. The uppermost level has been driven eastward in volcanic ash. The lode is a brecciated quartzose rock containing pyrites with some blende and galena. Some of the veinstone consists of saccharoidal quartz interspersed throughout with diminutive grains of galena. The small crystals of quartz are bipyramidal.

The output of lead-ore between 1857 and 1890 amounted to 140 tons.

COED-GWYDYR MINE, TREFRIW.

(Standing.)

Mrs. E. A. Pickford, Weathercote, Victoria Park, Colwyn Bay.

Level situated beside the Conway road, half a mile north of Trefriw, near Llanrwst. Fig. 12, No. 11.

Maps.—New Series One-inch Ordnance 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carmarvonshire 13 S.E.

The country-rock consists of sediments of Bala age.

The ore occurs in a zone of brecciated black slaty rock re-cemented with calcite and in places with quartz; the principal cementing material, however, is the ore itself. This consists mostly of galena, but blende is common also, and there is a small amount of pyrites.

An adit has been driven westwards into the lower slopes of the valley side.

GELLI-LYDAN MINE, TREFRIW.

Mr. Dunstan, Gelli-lydan Mine, Trefriw.

Levels situated at Gelli-lydan, on the northern side of the Crafnant valley, three quarters of a mile west of Trefriw. Fig. 12, No. 12.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 13 S.E.

The country-rock consists of Bala slates with intrusive greenstone. There is no true lode; the ore is contained in a faulted zone of rock re-cemented with calcite and permeated with galena. In some of the igneous rock the galena occurs in a manner suggestive of an original constituent; elsewhere it is embedded in large plates of calcite, the galena being finely granular. In the levels, quartz was practically absent, and there was very little calcite. The ore-body is 4 to 5 feet wide and dips northward at 45°. There are two more bands of mineralized rock a little higher up the mountain slope. Two levels have been driven, one from west to east, the other from south to north.

Water presents no difficulty. It is proposed, when the mine is in full work, to convey the ore down to the road by an aerial ropeway.

PANT-Y-CARW LEVEL, TREFRIW.

(Idle.)

Level situated on the south side of Pant-y-carw greenstone-quarries, by the side of the main road about 5 furlongs south of Trefriw. Fig. 12, No. 13.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 N.W.

The country-rock consists of Bala shales, ashes and greenstone.

A day-level has been driven westward for 400 yards. For the first 40 yards it traverses blue shales; it then turns northward and enters greenstone. The lode courses east and west and is a little over a foot wide in places. The gangue consists of quartz and calcite, with some manganese ore.

About a ton of lead-ore was got during 1919.

TY'N-TWLL MINE, LLANRWST.

(Standing.)

Shafts and levels situated at Ty'n-twll, a mile south-south-east of Trefriw. Fig. 12, No. 14.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 N.W.

The country-rock consists of ashes and sediments of Bala age.

There are two lodes, one coursing north and south, the other east and west. Both lodes are practically vertical.

This is an ancient mine that stopped work about 50 years ago on account of water troubles; but it is said to have had up to that time an output of lead-ore ranging from 100 to 200 tons per month. The mountain side is scarred with open-cast workings, and there are also shafts and levels.

On the dumps the vein-stone consists of brecciated slate and ash cemented with quartz and calcite, and occasionally vugs lined with schiefer-spar occur. The ores are galena and blende with some pyrites. Two periods of mineralization are represented; the first, when the breccia was cemented with calcite and quartz, and the second, after a period of movement, when most of the lead and blende gained access to the broken vein-stone and re-cemented it.

Between 1857 and 1875 the output of lead-ore amounted to 372 tons, which yielded 282 tons of lead. A part of this lead contained 5 ozs. of silver per ton.

TAN-YR-EGLWYS MINE, LLANRWST.

(*Idle.*)

Levels situated about a quarter of a mile south of Llanrhy-chwyn Church and $2\frac{1}{2}$ miles by road from Llanrwst Station (L. & N.W.R.). Fig. 12, No. 15.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 18 N.E.

The country-rock consists of Bala slates overlain by greenstone. At the junction of the igneous rock and the slate, mineralized waters are thrown out, and deposit on the slate a coating of hydrozincite and limonite.

Llanrhychwyn Slate Quarry is said locally to be the oldest slate quarry in Wales. The slate dips west at about 30° and is overlain by massive igneous rock of grey colour ('*carreg lwyd*'). The slate has been mined for hundreds of feet both in depth and also laterally, and in the workings near the southern end of the dumps a mineral lode was exposed. This lode courses nearly west and east, is nearly vertical, and about 3 feet thick. The ore consists chiefly of pyrites with some galena in a gangue of brecciated black slate of the country-rock, cemented with quartz and calcite.

At Tan-yr-eglwys the level is said to be over 400 feet long, but is not in good order. Another level has been driven on a small parallel vein of low grade. Another lode, on the eastern side of the valley, was worked in a short level at the Llanrhychwyn Mine.

The ore was broken and treated by a water-separation process of primitive type.

The mine has recently (1919) been taken over by the Klondyke Company (*see* p. 67), and it is proposed to carry the ore by aerial ropeway to the mills near Llyn-Geirionydd for treatment.

FFRITH-SIAN MINE, LLANRWST.

The Crafnant and Devon Mining Co., Ltd., 175, Piccadilly, W. 1.

Levels situated on the western slope of the Nant-Gwydyr valley, a mile south-west of Llanrwst. Fig. 12, No. 16. This mine has been called the Ty'n-yr-ardd Mine.

Maps.—New Series One-inch Ordnance, 106 (Bangor); Old Series Geological, 78 S.E.; six-inch, Carnarvonshire 19 N.W.

The country-rock consists of sediments and felspathic ashes of Bala age.

The two lodes are called respectively the Principal Lode and the North-and-South Lode.

The Principal Lode courses nearly east and west, underlies north at about 70° from the horizontal, and is about 4 feet wide. It has good walls. The gangue consists of calcite and quartz. The chief ore is galena, which forms 4 per cent. of the lode material; but some blende and pyrites also occur. The walls of the lower levels are coated, in places thickly, with hydrozincite.

Three levels have been driven into the steep slopes of the western side of the valley. In October, 1919, the lower level, which is used for drawing the ore, was 300 feet long, and was being opened up by underhand stoping. The middle level was 200 feet long, and contained good lead values. The upper level was about 400 feet in length.

The North-and-South Lode underlies east and is about 18 inches in width.

CILCENUS MINE, LLANRWST.

(*Standing.*)

The Cilcenus Mining Co., Ltd., Scotland Bank, Warrington.

Levels situated about 100 yards to the south and south-east of Cilcenus Farm, $2\frac{1}{4}$ miles south-south-east of Llanrwst. Fig. 12, No. 17. The mine is in Denbighshire, but is more conveniently grouped with the Carnarvonshire mines of the Llanrwst District.

Maps.—New Series One-inch Ordnance, 107 (Denbigh); Old Series Geological, 78 S.E.; six-inch, Denbighshire 16 N.W.

The country-rock consists of black silicious mudstones and shales of Bala age. The lode courses nearly east and west, is nearly vertical, and about 3 feet wide. Its gangue consists of brecciated country-rock that has been cemented together with quartz and afterwards re-brecciated and re-cemented with blende and some galena. The ore is frequently crystalline, small crystals of blende forming linings to vughs in the gangue. Galena and calcite are both of rare occurrence, and pyrites is seen only occasionally.

A day-level has been driven along the lode in the wood south-east of Cilcenus Farm, and there is a lower level lying about 100 yards south-west of the farm.

In October, 1919, several tons of ore were in stock by the lower dumps.

TRECATELL MINE, CONWAY.

The Trecastell Lead Mines, Ltd., 60-62, Spring Gardens, Manchester.

Shafts situated near Trecastell, about three quarters of a mile north east of Llangelynnin old church, 3 miles south west of Conway. The mine was formerly called the *Pyllau-cochion* or Red Pits, and is said to have been worked by the Romans.

Maps.—New Series One-inch Ordnance, 106 (Bangor). Old Series Geological, 78 S.E.; six inch, Carnarvonshire 8 N.E.

The country-rock consists principally of bedded ash of Bala age dipping nearly due east and slightly altered in parts of the mine by intrusive sills of greenstone. There is a bed of hard black chert, which consists of a breccia re-cemented with quartz and dipping at a high angle throughout the mine.

There are two principal lodes, shown on the Geological Survey Map, one coursing north-west and south-east, the other nearly due east and west. The east-and-west lode is known as the Main or Principal Lode. It underlies slightly south but is nearly vertical, and varies in width from 10 inches up to 6 feet, with an average of about 4 feet. This lode gives off two shoots known respectively as the No. 2 Lode and the No. 3 Lode.

The Aberllyn Lode courses north-west and south-east and either underlies north-east or is vertical.

The Main Lode cuts across the junction of the greenstone and ash, but appears to be faulted out by the Aberllyn Lode, as it has not been found east of that lode. A bed of black chert, varying from 20 to 60 feet thick, is cut through by the Main Lode between the 65- and the 85-fathom levels. The lode becomes impoverished in the chert, but below it the ores of lead and zinc reappear with an abundance about equal to that of the parts above the chert-bed. This change does not affect either the thickness of the lode or the nature of its walls; calcite and quartz form the entire filling while in the chert, but decrease greatly in quantity in the ash-beds.

The Aberllyn Lode consists mainly of blende with only small amounts of galena, while the Main Lode contains about 75 per cent. of zinc-ore and 25 per cent. of lead-ore. During fifty years of work the average for all the lodes was 60 per cent. of blende and 40 per cent. of galena. In the lode-stuff the proportion of galena was 10 per cent., and of blende 14 per cent. Dry assays of the ores indicated metallic zinc up to 56 per cent. with an average of 53; of lead, 80 per cent.; and of silver, from 13 to 18 ozs. to the ton.

The Main Lode is being worked at the 95 fathom level, the chert-rock being still found at the southern end of the workings. Examination of the material now being raised (Oct., 1919) shows the country rock to be all of igneous origin and chiefly grey bedded ash, sometimes felspathic, and 'black rock,' in parts felspathic but more often hard and cherty.

Next to the lode the country-rock is in some places a breccia, but normally the blende and galena lie immediately adjacent to the ash without any brecciated country-rock or spar. In this respect the lode differs entirely from the group of lodes around Llanrwst, where the brecciated ash has been mineralized, and clean-cut fissures are rare. A fair proportion of the 'best' ore forms lumps in the ash, some of it having the appearance of detritus. Other parts of the lode, but less commonly, consist of a gangue of calcite with seams, strings, and lumps of galena and blende. Granular blende in a calcite matrix without galena, or of granular galena without blende, appear to be characteristic of certain restricted parts of the lode. Large masses of blende also occur, mostly in the Aberllyn Lode. Calcite is of frequent occurrence, especially in vughs, in the form of wide leaf-shaped crystals up to 3 inches in width, which form beautiful objects, especially when parts of the crystals are tinged with a pinkish hue.

Much of the ore consists of an intergrowth of galena and blende, in which case the two minerals are so intermixed as to be inseparable by hand.

The mine is worked by shafts and levels. Adit-level lies at 15 fathoms below the surface at the winding-shaft, and below it are eight other levels, at 25, 35, 45, 55, 65, 75, 85 and 95 fathoms respectively. Work on the Main Lode in October, 1919, was being done at the 85- and 95-fathom levels. On the Aberllyn Lode work was proceeding at that date at the 35-, 45-, and 75-fathom levels.

Water presents no serious difficulty. It is raised from the sump by a one-gear compound pumping-engine, working two plungers and a driver. It is all used in dressing the ores.

The Table below gives the recent output of Trecastell Mine. By comparing these figures with the outputs of the other mines in Carnarvonshire, Merioneth, and Anglesey, it will be observed that Trecastell has been the principal producer of lead and zinc ores in this part of North Wales.

Output of the Trecastell Mine.

| Year. | Lead Ore. | Per- cent. of Lead in Ore. | Lead obtained. | Silver obtained. | Zinc Ore. | Per- cent. of Zinc in Ore. | Zinc obtained. |
|----------|-----------|--|-------------------|---------------------|-----------|--|-------------------|
| | Tons. | | Tons. | Ozs. | Tons. | | Tons. |
| 1892 - - | 12 | 64 | — | — | 60 | 60 | — |
| 1893 - - | 12 | 74 | — | 58 | — | — | — |
| 1894 - - | 80 | 82 | — | 265 | 215 | 49 | — |
| 1895 - - | 1½ | 82·5 | 1 | 13·5 | 280 | 56·5 | 124 |
| 1896 - - | 384 | 81·5 | 297 | 5,302 | 1002 | 53 | 415 |
| 1897 - - | 282 | 81 | — | 4,176 | 800 | 48 | 299 |
| 1898 - - | 280 | 81 | 215 | 3,586 | 387 | 46 | 138 |

| Year | Lead Ore. | Per cent. of Lead in Ore | Lead obtained | Silver obtained | Zinc Ore | Per cent. of Zinc in Ore | Zinc obtained |
|------|-----------|--------------------------|---------------|-----------------|----------|--------------------------|---------------|
| | Tons. | Tons. | | Oz. | Tons. | | Tons. |
| 1890 | 566 | 81 | 435.5 | 7,815 | 583 | 50 | 227.5 |
| 1900 | 512 | 81 | 394 | 7,582 | 809 | 50 | 316 |
| 1901 | 550 | 80 | 418 | 7,596 | 969 | 50 | 378 |
| 1902 | 691 | 80 | 525 | 10,234 | 1063 | 50 | 415 |
| 1903 | 620 | 80 | 471 | 9,182 | 1089 | 50 | 425 |
| 1904 | 365 | 78 | 270 | 5,043 | 918 | 50 | 358 |
| 1905 | 322 | 79 | 242 | 4,287 | 716 | 50 | 279 |
| 1906 | 290 | 77 | 212 | 3,717 | 771 | 50 | 300.5 |
| 1907 | 301 | 80 | 229 | 3,856 | 717 | 50 | 280 |
| 1908 | 251 | 76.5 | 182 | 3,218 | 604 | 50 | 236 |
| 1909 | 213 | 76.5 | 155 | 2,730 | 455 | 50 | 177 |
| 1910 | 184 | 78.5 | 137 | 2,358 | 323 | 48 | 121 |
| 1911 | 296 | 79 | 222 | 3,793 | 415 | 44 | 152 |
| 1912 | 90 | 79 | 68 | 1,350 | 97 | 50 | 38 |
| 1913 | 146 | 74.6 | 103 | 2,064 | 241 | 40.7 | 77 |

ANGLESEY.

MONA, PARYS AND MORFA-DU MINES, AMLWCH.

The Mona and Parys Mine, Ltd., Amlwch, Anglesey.

The mine is situated on Parys Mountain, about $1\frac{1}{2}$ miles south of Amlwch and 2 miles by road from the railway-station. Before conjoint ownership the western part was called Parys Mine, the eastern part Mona Mine; the Morfa-du Mine was situated at the extreme western end of the mountain.

Maps.—New Series One-inch Ordnance, 93 (Holyhead); Old Series Geological, 78 N.W.; six-inch, Anglesey 3 S.W.

The following account is derived mainly from Dr. E. Greenly's *Memoir*¹ :—

The country-rock consists mainly of Silurian and partly of Ordovician shales with a sill of felsite several hundred feet in thickness at or near their junction, the structure being that of a deep isoclinal infold bounded and traversed by faults. In varying degrees the rocks are silicified, micacized and pyritized. The lodes, most of which range south of west and north of east, are not true fissure-veins, but zones of maximum chalcopyritization, where the mineral changes took place partly during, but chiefly just after, the great post-Silurian earth-movements. There is said to have been observable a sort of rough order in the arrangement of the ores: pyrites on the north, chalcopyrite in the middle, and 'bluestone' (p. 82) on the south, though no part was free from pyrites. The bluestone is the source of lead and zinc.

¹ 'The Geology of Anglesey' (*Mem. Geol. Surv.*), 1919, vol. ii, p. 823.

The mode of occurrence of the ore in the Great Lode can still be observed at the old engine-house in the middle of the West Pit. In rock more or less pyritized throughout are great lenticular or ellipsoidal overlapping aggregates, elongated along the strike, of pyrites-cubes that are so closely crowded as to leave barely enough matrix to bind them together. The lode appears to be a series of such aggregates, the bluestone zone (which is said to have varied from a few inches to 50 or 60 feet in width) having been a range of impregnations of similar form. The matrix of the aggregates is quartz, granular and decidedly fine, and very free from chlorite. Here and there, thin strings of ordinary vein-quartz cut it, and these are usually much freer from sulphides.

The Great Lode appears to have been a pair of huge groups of lenticular aggregates or impregnations, lying in more or less silicified and pyritized shale. Those along a southern zone, 50 or 60 feet in width, were bluestone.

The Clay Shaft Lode in the East Pit was 54 feet wide, but is said to have attained a thickness of 140 feet with a dip of about 25° , and consisted of bunches or swellings. Bluestone appears to have been the principal ore.

The Black Rock Lode formed a junction with this lode and consisted chiefly of bluestone. Other lodes were known as the Golden Venture, the Careg-y-doll, Charlotte's, and the North Discovery Lodes.

The Morfa-du Lode lies at the western extremity of the mountain, in the Phyllograptus Shales below the felsite, ranges north and south, and dips westward. It is a bluestone lode, but is not a silicified shale. Pyrites and chalcopyrite are frequent in the bluestone, but blende is not conspicuous. The workings are said to have been shallow, and the lode a series of ill-defined impregnations like most of the bluestone lodes.

The Great Lode had a gossan of greasy clay containing from 600 to 1,000 lbs. of lead-ore per ton, which, however, was difficult to smelt.

The following passage from Dr. Greenly's Memoir throws light on the nature of the ore locally known as bluestone :—

“ ‘Bluestone’ is a dark bluish-grey material, very heavy, granular, and rather fine in texture. Tracts of fine pyrite and chalcopyrite can be seen among the grey body, which is lit up with innumerable little flashes from some brilliant metallic-looking ‘glance.’ Sometimes blende can be detected with the hand-lens, and in powder under the microscope is seen to be abundant. Two typical bluestones, supplied by the captain of the mine, Mr. Hughes, have been sliced [E. 9421-2]. Dr. H. H. Thomas describes them as follows :—‘The main mass of the ore consists of a deep-yellow zinc-blende which appears, with the quartz, to be the earliest-formed portion of the lode. The blende is much fissured, and traversed by a network of minute cracks which carry chalcocite, galena, and pyrite. It would appear that the introduction of the galena and pyrite followed that of the chalcocite. . . .’ Bluestone is, therefore, an intimate intergrowth of pyrite, chalcopyrite, chalcocite, blende, and galena, with a little quartz, in

varying proportions. Its complexity has been a serious hindrance to smelting."¹

The following Tables of analyses, showing the chemical composition of the bluestone and its associated ores, are taken from the same source :—

| | I | II | III | IV | V | VI |
|--------------------|--------------------------|-------------------------|------------------------|------------------|--------------------------|-----------------------------------|
| Pb - | 14.46 | 11 to 13 | 14 to 15 | 1.00 | .15 | .10 |
| Cu - | 2.13 | .5 to 1 | 2 | 3.80 | 6.26 | 4.41 |
| Zn - | 27.89 | 30 to 32 | 30 to 33 | 12.21 | 1.20 | — |
| Fe - | 11.45 | 14 to 16 | — | 10.33 | 26.25 | 23.80 |
| S - | 29.05 | 24 to 26 | — | 18.40 | 27.05 | 23.75 |
| MgO - | — | — | — | — | .90 | 1.10 |
| SiO ₂ - | 14.47 | 16 to 18 | — | 53.65 | 37.15 | 45.24 |
| O - | — | — | — | .61 | 1.04 | 1.60 |
| Total | 99.45 | — | — | 100.00 | 100.00 | 100.00 |
| Ag - | per ton 6 oz. 15 dwt. | per ton 10 to 14 oz. | per ton 8 to 10 oz. | per ton 5 oz. | per ton 2 oz. 10 dwt. | per ton 3 oz. 7 dwt. 12 gr. |
| Au - | traces | 2 to 3 dwt. | 2 dwt. | 1 dwt. 12 gr. | 1 dwt. 12 gr. | 2 dwt. |

I—Bluestone. Old analysis by Claudet.

II—Bluestone. Anal. C. H. Hills of the Amlwch Chemical Works.

III—Bluestone. Anal. not named.

IV—Approaching a bluestone. Blackrock Shaft. Anal. Johnson & Sons. 23, Cross Street, E.C. 'O' includes traces of As and Mn.

V—Probably pyrite, chalcopyrite and quartz. Gwen Shaft. Anal. Johnson & Sons. 'O' includes traces of Mn and Bi.

VI—Probably quartz with pyrite, chalcopyrite and chlorite. Quarry Shaft. Anal. Johnson and Sons. 'O' includes traces of Mn and Zn.

Nos. III-VI were supplied by Mr. Fanning-Evans. No specimens of the analysed ores have been preserved.

The following Table, showing the quantities of lead and silver obtained from the bluestone, is based on the Home Office Statistics :—

| Year. | Mona Mine. | | Morfa-du Mine. | |
|----------|---------------|-------------------|----------------|-------------------|
| | Tons of Lead. | Ounces of Silver. | Tons of Lead. | Ounces of Silver. |
| 1882 - - | 62 | 5,535 | 87 | 5,982 |
| 1883 - - | 161 | 3,740 | 20 | 1,197 |
| 1884 - - | 157 | 7,700 | — | 770 |
| 1885 - - | 32 | 3,800 | — | — |
| 1886 - - | 93 | 8,341 | — | — |

¹ E. Greenly, *op. cit.*, pp. 827-8.

| Year. | Mona Mine. | | Morfa-du Mine. | |
|---------|---------------|-------------------|----------------|-------------------|
| | Tons of Lead. | Ounces of Silver. | Tons of Lead. | Ounces of Silver. |
| 1887 | - | 168 | 41 | 2,596 |
| 1888 | - | 42 | 21 | 2,668 |
| 1889 | - | — | 14 | 560 |
| 1890 | - | — | 14 | 3,600 |
| 1891 | - | — | 64 | 4,900 |
| 1892 | - | — | 44 | 4,219 |
| 1893 | - | 35 | 61 | 4,655 |
| 1894 | - | 54 | 73 | 5,482 |
| 1895 | - | 80 | 2 | 159 |
| 1896 | - | 93 | 7 | 598 |
| 1897 | - | 133 | — | — |
| 1898 | - | 40 | — | — |
| 1899 | - | 7 | 1 | 40 |
| 1900 | - | 3 | 4 | 310 |
| 1901 | - | 25 | 8 | 698 |
| 1902 | - | 14 | — | — |
| 1903 | - | 6 | 5 | 468 |
| 1904 | - | 5 | 31 | — |
| 1905 | - | 14 | — | — |
| 1906-10 | - | nil | nil | nil |
| 1911 | - | 38 | — | — |

The following Table (from the same source) gives the output of bluestone and the percentage of zinc therein :—

| Year. | Mona Mine. | | Morfa-du Mine. | |
|-------|--------------|-------------------|----------------|-------------------|
| | Tons of Ore. | Percent. of Zinc. | Tons of Ore. | Percent. of Zinc. |
| 1866 | - | 1,221 | — | — |
| 1867 | - | 765 | — | — |
| 1868 | - | 1,078 | — | — |
| 1869 | - | 879 | — | — |
| 1870 | - | 1,200 | — | — |
| 1871 | - | 200 | — | — |
| 1872 | - | 984 | — | — |
| 1873 | - | 414 | — | — |
| 1874 | - | 1,008 | — | — |
| 1875 | - | 500 | — | — |
| 1876 | - | 50 | — | — |
| 1877 | - | — | — | — |
| 1878 | - | 360 | — | — |
| 1879 | - | 548 | — | — |
| 1880 | - | 1,569 | — | — |
| 1881 | - | 1,469 | 836 | — |

| Year. | Mona Mine. | | Marta-la Mine. | |
|--------------|-------------|------------------|----------------|------------------|
| | Tons of Ore | Percent of Zinc. | Tons of Ore | Percent of Zinc. |
| 1882 | 514 | — | 726 | — |
| 1883 | 1,239 | — | 171 | — |
| 1884 | 1,100 | 33 | 115 | 30 |
| 1885 | 320 | 36 | — | — |
| 1886 | — | — | 697 | 30 |
| 1887 | 1,361 | 28 | 335 | 28 |
| 1888 | 520 | 30 | 297 | 25-30 |
| 1889 | — | — | — | — |
| 1890 | — | — | — | — |
| 1891 | — | — | 500 | 29 |
| 1892 | — | — | 470 | 28 |
| 1893 | 270 | 28 | 470 | 28 |
| 1894 | 405 | 29 | 550 | 29 |
| 1895 | 600 | 29 | 16 | 29 |
| 1896 | 700 | 32 | 50 | 32 |
| 1897 | 1,000 | 32 | — | — |
| 1898 | 300 | 32 | — | — |
| 1899 | 53 | 30 | 4 | 30 |
| 1900 | 35 | 30 | 40 | 30 |
| 1901 | 224 | 33 | 70 | 30 |
| 1902 | 122 | 33 | 2 | 33 |
| 1903 | 73 | 25 | 67 | 25 |
| 1904 | 67 | 22 | 367 | 24 |
| 1905 | 250 | 15 | — | — |
| 1906 to 1910 | nil | nil | nil | nil |
| 1911 | 455 | 25 | — | — |

Bluestone raised at Parys Mountain Mine amounted in 1868 to 70 tons, in 1875 to 150 tons, in 1876 to 7 tons, and in 1902 to 17 tons.

H. D.

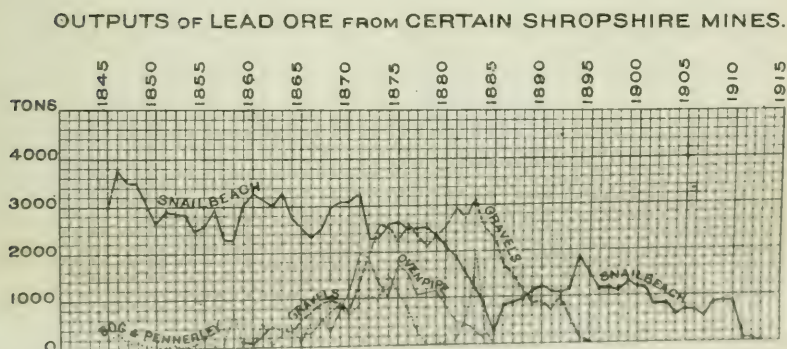
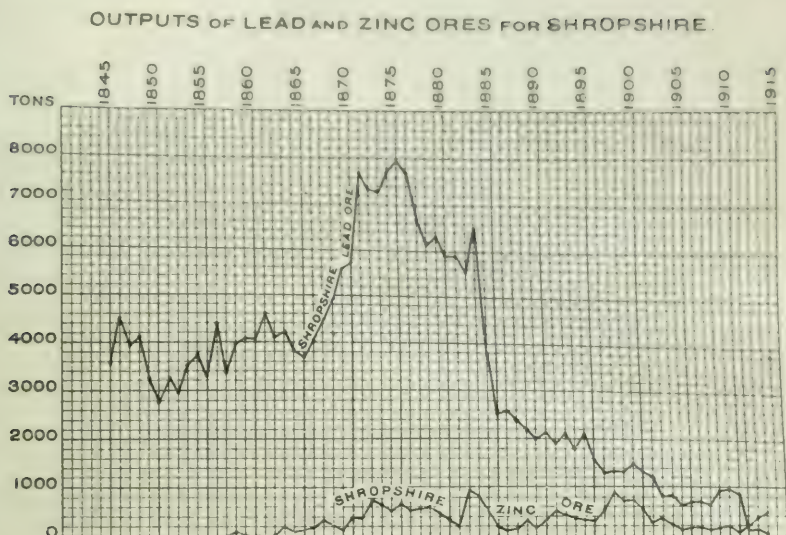
APPENDIX.

PLANS OF ABANDONED MINES.

Plans of some of the abandoned lead and zinc mines referred to in this volume (and of others not mentioned therein) are preserved at the Home Office. The following list is collected from the official Blue Book: 'List of the Plans of Abandoned Mines deposited in the Home Office,' 1920. Plans with the letter R prefixed to the number, and also those of all mines that had been abandoned for more than ten years by 31 Dec. 1919, are open to inspection.

The last column in the following list gives the page of the present volume on which the mine is mentioned.

| <i>Register Number.</i> | <i>Name of Mine.</i> | <i>Post-town.</i> | <i>Ores worked.</i> | <i>Date when received.</i> | <i>Page in text.</i> |
|-------------------------|-------------------------------|-------------------|---------------------|----------------------------|----------------------|
| SHROPSHIRE. | | | | | |
| 3055 | Burgam - - - | Minsterley - | Lead and Zinc. | 2.2.1894 | 26 |
| R. 47 | Bog - - - | " - | Lead | — | 29 |
| 4253 | Grit - - - | " - | Zinc and Lead | 31.5.1902 | 19 |
| R. 71 | Grit, East - - | Shelve - | Lead | — | 19 |
| 3351 | Roman Gravels - | Minsterley - | Lead and Zinc. | 11.10.1895 | 15 |
| 4262 | Roman Gravels, East | " - | Lead and Zinc. | 9.6.1902 | 14 |
| 1383 | Roman Gravels, South | " - | Lead | 7.8.1882 | 22 |
| 3056 | Tankerville - - | " - | Lead and Zinc. | 2.2.1894 | 26 |
| MONTGOMERYSHIRE. | | | | | |
| 1697 | Bwlch-creolen - - | Penygarnedd | Silver-lead. | 12.5.1885 | 44 |
| DENBIGHSHIRE. | | | | | |
| 5044 | Llanfair - - - | Abergele - | Lead and Zinc. | 12.3.1907 | 47 |
| MERIONETH. | | | | | |
| R. 50 | Bont-ddu and Vigna - | — | Lead | — | — |
| R. 157 | Caegwion - - - | Bont-ddu - | Lead | — | — |
| R. 158 | Cwmheisian - - | Dolgelley - | Silver-lead. | 1844 | — |
| 1695 | Melin-Llyn-Pair - | Towyn - | Silver-lead. | 6.3.1885 | — |
| CARNARVONSHIRE. | | | | | |
| 1812 | Aberllyn - - - | Bettws-y-coed | Zinc | 4.9.1885 | 62 |
| 4993 | Aberllyn and Pen-yr-allt. | " | Lead and Zinc. | 26.11.1906 | 62, 64 |
| 1538 | Assheton and Port-Nigel. | Abersôch - | Lead | 21.11.1883 | 58 |
| 1902 | Bettws-y-coed (Cyff Consols). | Bettws-y-coed | " | 3.11.1885 | 72 |
| R. 159 | Caegwernog and Berth-lwyd. | — | " | 1846 | — |
| 1812A | Clementina - - | Llanrwst - | " | 4.9.1885 | — |
| 2704 | D'Eresby and Gwydyr | " - | " | 23.4.1892 | — |
| 1812 | Griffin - - - | Bettws-y-coed | Zinc | 4.9.1885 | — |
| 4910 | Parc and Fuches-lâs - | Llanrwst - | Lead and Zinc. | 3.5.1906 | 65 |
| R. 194 | Penrhyn-du - - | Abersôch - | Lead | 1851 | 58 |



GRAPHS SHOWING OUTPUTS OF MINES.

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